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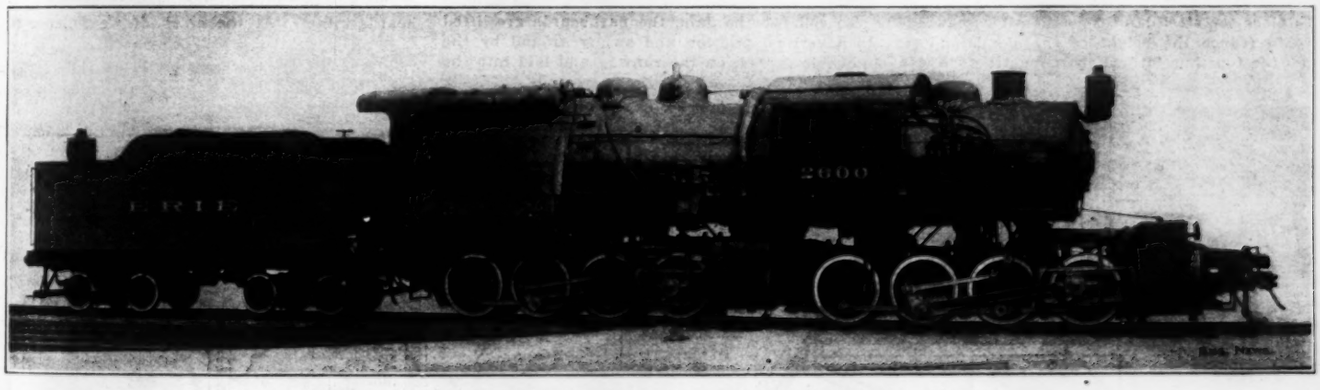
PUSHER LOCOMOTIVES OF THE MALLET DUPLEX TYPE FOR THE ERIE RY.

The Mallet duplex type of locomotive, in which one set of driving wheels is carried in a steam truck under the front end, is now in use on three railways in this country, the latest engines being for the Erie Ry. This type was first introduced for pusher service on the Baltimore & Ohio Ry., the engines being of the 0-6-6-0 class and weighing 334,500 lbs. The Great Northern Ry. then adopted it for regular road service, for which reason pony trucks were added, making the arrangement 2-6-6-2. These weigh 355,000 lbs., but have only 316,100 lbs. on the driving wheels. The engines for the Erie Ry. are for pusher service, but are larger and heavier than the others and are of the 0-8-8-0 class. The former engines have been described and illustrated in our issues of June 30, 1904; June 15, 1905, and Sept. 27, 1906. They are all very much the same in design. We illustrate herewith one of the three immense new engines for the Erie Ry., which have been built at the Schenectady works of the American Locomotive Co. They weigh 410,000 lbs. and are by far the heaviest locomotives in the world, although the axle load (51,250 lbs.) is lower than that of many locomotives now in service. However, the effect of such an enormous load upon track and rail joints may be imagined.



MALLET COMPOUND DUPLEX LOCOMOTIVE FOR PUSHER SERVICE; ERIE RY.
T. Rumney, Mechanical Superintendent; American Locomotive Co., Builders.

The boiler is of the wagon-top pattern, with a radial-stay Wootten firebox having a 4-ft. combustion chamber supported by radial stays. The heaviest barrel plates are $1^{3}/_{16}$ ins. thick. The boiler carries some 42,700 lbs. of water, and its total weight (with normal charge of water) is nearly 70 tons. As the engine will run backward as much as forward the dome (which is of cast steel) is placed near the middle of the boiler, behind the cab, and is on the conical boiler course. At the throttle, the steam enters at the top, and any entrained water strikes the sides of a casting above the valve, passing down through the valve instead of going with the steam into the dry pipe. This pipe extends forward inside the boiler to a point in line with the high pressure (rear) cylinders; here it is led through the shell to a T-head and connects with pipes passing down on each side of the boiler to the steam chests. The high pressure exhaust passes into a 9-in. receiver pipe extending forward from the saddle, to which it is connected by a ball joint; at the forward end it has a slip-joint connection with a Y-pipe to the low-pressure steam chests. The receiver pipe is made in three sections, and is laid out to allow for 16° curves. The arrangement is the same as on the Baltimore & Ohio Ry., where it has given no trouble from leaky joints in two years of service. The low-pressure cylinders are on the steam truck, and considerably in advance of the boiler. Their exhaust is carried back through a pipe with flexible connections to the exhaust pipe in the smokebox. The engine can be worked as a simple engine when required, the intercepting valve being in the upper part of the left-hand high-pressure cylinder casting. There is also an emergency exhaust valve, with a pipe carrying the high-pressure exhaust direct to the exhaust pipe when working simple.

Piston valves are used on the high-pressure cylinders and balanced slide valves on the low-pressure cylinders. The Walschaert valve gear is used, and the reversing gear is so arranged that the weights of the front and rear valve gears counterbalance each other. As the high-pressure valves are of the internal admission, and the low pressure valves of the external admission type, it was possible (with this arrangement of reversing gear) to obtain a satisfactory valve motion with both return cranks (or eccentric cranks) leading the pin; the rear engines then take the forward motion from the top of the link, while the front engines take it from the bottom of the link. Pneumatic reversing cylinders are used.

The frames of the steam truck and under the rear end are of cast steel, 5 ins. wide. The steam truck pivots at its rear end on an articulated connection to a cross brace between the fixed frames. The boiler is supported on this truck by a self-adjusting sliding bearing between the third and fourth driving-wheels. This consists of a built-up saddle casting which bears upon a cast-steel cross-tie directly below it, through a wrought iron case-hardened sliding plate. A brass wearing plate is introduced between the casting and wrought iron plate. The sliding plate is radially planed on the bottom so that it adjusts itself to the alinement of the engine. Movement in a vertical direction is prevented by a safety connection between the casting and the cross-tie, which prevents the frame from dropping away from the boiler in case of any derailment. There is also a similar safety connection provided at the front end of the boiler between the guide yoke casting and the exhaust pipe elbow. Another sliding support is located between the second and third pair of driving-wheels, and is so adjusted that it does not take any of the load except under unusual conditions due to inequalities in the roadbed. It is provided with a floating balance device which serves to take some of the load off the main boiler bearings. This device consists of a pair of columns, one on either side of the center of the engine, free to sway as the engine turns in passing around curves. Each column has a ball-joint connection at the upper end with a saddle casting bolted to the boiler, and a ball-joint connection at the lower end with a flap casting hinged to the bottom of a cross-tie across the lower rails of the frame. Around the outer ends of these hinged castings are U-bolts which extend up through the bottom of the cross-tie and through coil springs seated on the cross-tie. These springs thus exert an upward force on the columns equal to the total compression of the springs. The initial total compression is 30,000 lbs., which can be increased by screwing down the spring caps by means of nuts on the ends of the U-bolts. This boiler support is also provided with a spring centering device.

The four pairs of front driving-wheels are equalized together on each side, and equalized transversely in front of the forward drivers, making this system equivalent to a single supporting point. The rear driving-wheels are equalized only on each side, without cross equalization. This arrangement forms a three-point suspension system. These engines are to operate between Susquehanna and Gulf Summit, 8 miles, where the ruling grade is 1.3%. With their aid, trains of 2,660 tons hauled by consolidation engines can ascend this grade. Their general dimensions are given below.

MALLET PUSHER ENGINES; ERIE RY.

Type of engine	0-8-8-0
Driving wheels, 16 (two groups); diameter	4 ft. 3 ins.
Wheelbase, driving (each group)	14 ft. 3 ins.
Total engine	39 ft. 2 ins.
Engine and tender	70 ft. 6 ins.
Weight (all on driving wheels)	410,000 lbs.
Cylinders h. p. (2)	25 x 28 ins.
Cylinders l. p. (2)	39 x 28 ins.
Ratio of area of h. p. to l. p. pistons	1 to 2.43
Crosshead and guides	Two bar; alligator
Valve gear	Walschaert
Boiler, smallest inside diameter	6 ft. 10 ins.
Firebox, type: Wootten, radial stayed; with combustion chamber.	
Firebox, size	120⅛ × 114¼ ins.
Combustion chamber, length	4 ft.
Water spaces, width at mud ring	5 ins.
Tubes; 404; diameter outside	2¼ ins.
Tubes, length	21 ft. 0 ins.
Heating surface: tubes	4,971 sq. ft.
Firebox and combustion chamber	343 sq. ft.
Total	5,314 sq. ft.
Grate area	95 sq. ft.
Tractive force (working simple)	94,800 lbs.

A COLLAPSIBLE STEEL DAM CREST, BEAR RIVER, NEAR GARLAND, UTAH.

By J. C. WHEELON.*

The Utah Sugar Co. has recently completed an improvement on its main dam, on Bear River, in Bear River Canyon, near Garland, Utah, about 35 miles above the point where this river empties into the Great Salt Lake. This improvement consists of a collapsible steel dam or dam crests invented by and constructed under the supervision of the writer.

To place the steel dam in position it was necessary to reduce the height of the old dam 5 ft. Upon the top thus formed the new structure was raised, which rises to the original height of the dam, but may be collapsed in time of high water, allowing the flood to pass over, carrying with it all driftwood and other stuff that would naturally increase the pressure and endanger the foundations of the dam.

*Chief Engineer, the Utah Sugar Co.'s Bear River Canals, Garland, Utah.

The steel addition to the dam, or it might be called a cresting, is attached to the main structure by hinges in such a way that when its services are not needed it folds down into a longitudinal pocket or slot in the main structure, thus reducing the height of the dam about 4 ft., and eliminating the danger of the water cutting around the ends of the dam during floods and washing out the canals and headgates, and also reducing the pressure against the main dam. When the danger of the flood is over, the steel dam is raised into position and the water again impounded.

The total length of the dam is 400 ft., the whole distance of which is equipped with this device. The total height of the dam to the top of the steel portion is 17.6 ft.; the total height of the dam with the steel dam collapsed is 14.6 ft., giving a vertical distance in the clear for purposes of flood discharge of 3 ft.

A general view of the new collapsible crest is shown by Fig. 1 and the details of its construction are shown by Fig. 2. The crest is composed of steel bents, 8 ft. c. to c.; a steel runway or platform, with track, also made in 8-ft. sections; and inclined flashboards. The lower ends of the posts of the bents are hinged to anchor bolts in the top of the main dam. One end of each section of the platform is hinged to the top chord of each bent, and the foot of each flashboard rests in a notch cut in a large longitudinal timber, anchored to the top of the main dam.

To collapse the dam, the flashboards are lifted to a vertical position and swung around by the movable derrick on the runway and laid into the longitudinal pocket on the top of the main dam, being inserted through openings in the downstream side of the steel frames. The unhinged end of the runway is then pushed off the standing bent, and the detached section of runway and bent hinged thereto fold themselves upon each other as they fall into the basin or pocket of the dam. The next section is treated in the same way until as much of the dam as is required is sup[illegible]ged. In raising the dam, the loose end of the [illegible]way is grappled and raised, which action al[illegible]ses the prostrate bent to an upright positi[illegible]. The flashboards are inserted and the next [illegible]ate section is raised. When down, the steel [illegible] is safe from the floating logs, ice and othe[illegible]ris, which pass over the submerged pocket as [illegible]uld not exist.

FIG. 1. GENERAL VIEW OF COLLAPSIBLE STEEL DAM CREST FOR THE UTAH SUGAR CO., BEAR RIVER, NEAR GARLAND, UTAH.

The V-shaped longitudinal notch in the upper timber enclosing the pocket into which the lower end of the flashboards fit is kept clear by the action of the water. Moreover, the sticks and roots which pass over the dam are generally floating at the top or on the surface of the water, and are never down so low in the water as the lower ends of the flashboards.

Each flashboard is filed into the pocket under the bent next to the one from which it is taken, so we are in the shelter of a bent having flashboards intact. At the finish, if we collapse the whole length of the dam, we have one set of three flashboards to lay upon the embankment.

It should be understood that this dam is raised before the water subsides within possibly 2 or 3 ft. of the crest of the pocket. We do not let the water get more than 3 or 4 ins. below the level of our runway. When the flood water subsides to this extent, we begin raising the col-

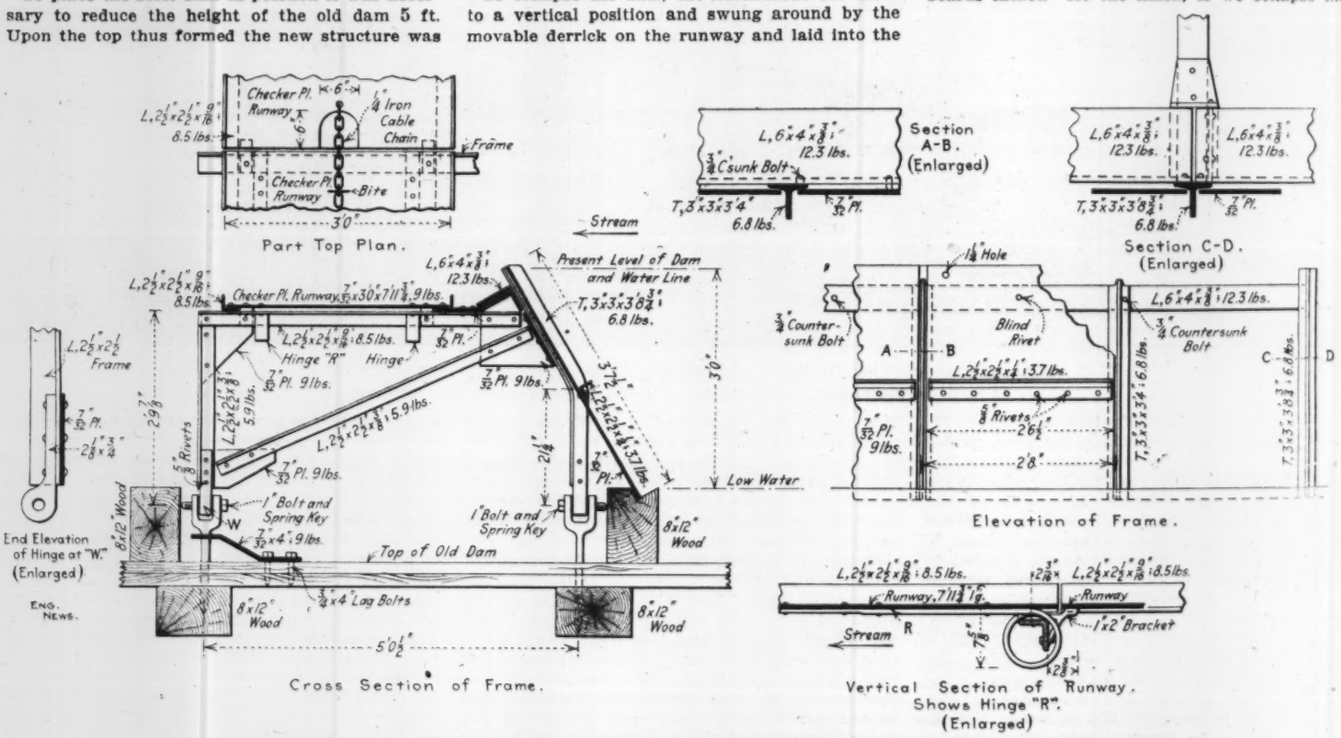


FIG. 2. DETAILS OF COLLAPSIBLE STEEL DAM CREST FOR THE UTAH SUGAR CO., NEAR GARLAND, UTAH.

lapsible dam in sufficient distance so that the spillway is contracted and less water will go through. We keep on as the water subsides until perhaps our dam is entirely raised and the small or minimum flow is passing over the raised dam entirely.

This collapsible crest can be attached to either masonry or timber dams with equal success. It recommends itself in the construction of new dams, as by incorporating this work for the upper 4 ft. or more the flood or excess waters are so completely under control that the factor of safety can be reduced and a much lighter cross-section can be used in construction than would otherwise be possible. In the case of an old wooden dam, a portion of the top of the dam can be removed, this crest can be installed and the old structure relieved of the extreme periodical strains, thereby prolonging its life. When a new dam is inevitable this steel dam can be reinstalled upon the new work.

In cases of earth dams, where a side spillway is designed for the discharge of flood and excess waters, this crest could be used to great advantage, dispensing with gates and posts, and thus increasing the open cross-sectional area of capacity without widening the spillway space. The crest converts a weir dam into an immense spillway and vise versa at will, leaving absolutely no obstructions to the freedom of discharge.

The device is being covered by patents. It is expected that arrangements will soon be made for its manufacture and shipment in sections, accompanied by drawings so that any mechanic can erect and install it. Each order, when completed, will be furnished with a car derrick for operating the crest.

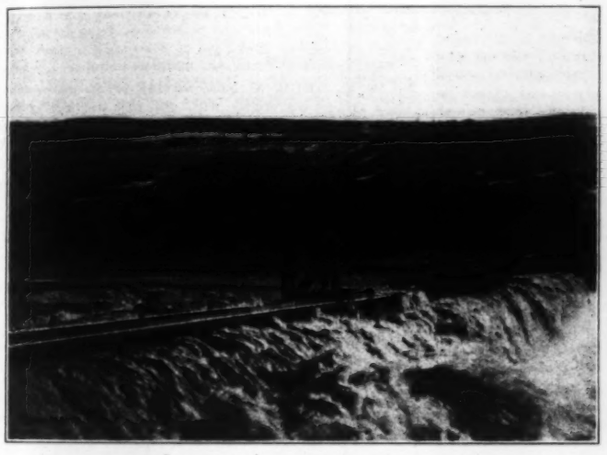


FIG. 3. LIFTING THE FLASHBOARDS.

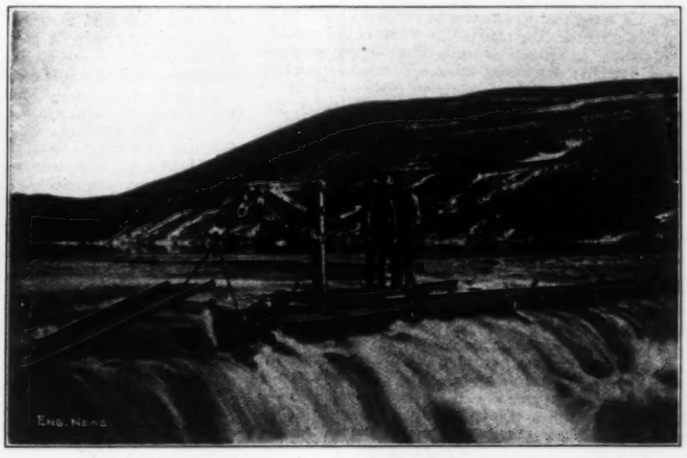


FIG. 4. LOWERING THE RUNWAY AND BENTS.

FIGS. 3 AND 4. COLLAPSING THE STEEL DAM CREST, UTAH SUGAR CO., NEAR GARLAND, UTAH.

RIVETED STEEL AND WOOD STAVE PIPE LINE data are being collected by Mr. Charles L. Parmelee, 90 West St., New York City. Blank forms have been prepared, in the hopes of obtaining information regarding as many pipe lines as possible. The information desired includes the length, diameter, thickness, working pressures, joints, preservatives used, costs of pipe and pipe laying, etc. Blanks can be obtained on request by applying to Mr. Parmelee at the address given.

A NEW GERMAN STREET CAR FENDER is described by Consul H. T. Norton, of Chemnitz, in the American consular reports of July 15 and Sept. 10. The only visible part of the mechanism is a projecting strip extending in front of the forward platform of the car and attached to a shaft or rod carried by the platform. If this strip comes in contact with any object it yields easily and forces the shaft backward. By this movement the electric current is cut off, an automatic brake is applied and a broad fender, some 3 ft. back, immediately in front of the wheels, drops to the rail level and picks up the object on the track. During the continuous daily experiments carried on for many months with animals and mannikins there has been no failure to pick up safely and easily all obstacles encountered. The device is controlled by the city council of Dresden. Illustrations are on file in the Bureau of Manufactures, Dept. of Commerce and Labor, Washington, D. C.

ENGINEERING STUDIES OF A TYPHOID OUTBREAK AT THE STATE HOSPITAL, TRENTON, N. J.

Interesting and suggestive studies of a typhoid outbreak at the State Hospital for the Insane at Trenton, N. J., have recently been made by a committee of the State Sewerage Commission of New Jersey, assisted by Prof. Earle B. Phelps, of the Massachusetts Institute of Technology, Boston, and others. The studies seem to show that the outbreak was largely due to the pollution of a portion of the water supply of the asylum by the sewage of the institution. The sewage backed up in a clogged sewer and passed a few hundred feet, through porous rock, to a walled spring nearly 25 ft. below. Mr. Phelps's investigations included the use of an aniline dye to establish the fact of a connection between sewage leakage and the spring; a repetition of the percolation effects due to stopping the flow through the sewer; gaging the spring flow during his stoppage of the sewer; determination of the rate of percolation; bacterial analyses; and a general survey of the sanitary conditions of the asylum, as related to the outbreak.

[Since our article based on the report of the State Sewerage Commission was put in type we have received later report on this outbreak, by Dr. Henry Mitchell, Secretary of the New Jersey State Board of Health. Dr. Mitchell's report, printed in full below, attributes the outbreak wholly to personal contact.]

Before proceeding with Mr. Earle's report a brief outline of the earlier investigations by the committee itself, may be given. The committee consisted of Messrs. H. M. Herbert, M. Am. Soc. C. E. (Bound Brook, N. J.), John H. Capstick and F. C. Jacobson, all members of the New Jersey State Sewerage Commission. Mr. Boyd MacLean, we may add, is secretary of the commission (1 Montgomery St., Jersey City, N. J.). The commission was appointed on July 25, 1907, as the result of a complaint made to the State Sewerage Commission that day by the hospital authorities, alleging that a part of its water supply had been polluted by sewage. The committee began its investigations at Trenton on July 26. It found that an 8-in. tile sewer had been laid past the hospital about two years ago by the city of Trenton, with no connection until after it passed the spring, save the one from the hospital itself. The grade of the upper end of the sewer was flat, and a flush tank had been provided at its head, but had never been used. On June 16, 1907, the hospital warden had seen sewage overflowing from a manhole opposite the spring, where the hospital connection joined the city sewer. A stoppage was found and removed. The committee had the sewer stopped at this and at a lower manhole, and found an undoubted leakage of the sewage into the surrounding rock. Two 4-oz. doses of permanganate of potassium, at three-hour intervals, failed to establish conclusively that the sewage to which it was applied reached the spring, but bacterial analyses of the spring water indicated sewage contamination, as did also dosing the sewage with 4 lbs. of red aniline dye solution, followed about 12 hours later with 10 lbs. additional. This dye was applied by Mr. J. C. Harding, associated with Hering & Fuller, New York City, who had the sewer plugged before the dye was used. The first dye was put in by Mr. Harding between 8 and 10 p. m., and the second between 8 and 12 a. m., next day. The dye appeared at the spring at 10:45 on the morning after its application and was "clearly noticeable" until 3 p. m., the color being strongest at 1.30 p. m. During the time the sewer was blocked the water level in the walled enclosure of the spring rose ½-in.

As a result of the investigation just outlined, and of the more thorough studies by Mr. Phelps, described further on, the investigating committee states as its belief that the spring should be closed. The State Sewerage Commission promptly requested the city of Trenton to repair the sewer and to place in operation the flush tank at its head.

Mr. Phelps's report to the New Jersey State Sewerage Commission contains so many interesting facts regarding both his tests and the typhoid outbreak that we publish it in full. It is dated Boston, Aug. 6, 1907, and is as follows:

I submit herewith a report on the results of my investigations at the New Jersey State Hospital, Trenton, relative to the possible pollution of the water supply of that institution by its own sewage. Although many of the facts relative to the case are well known to you, it seems proper at this time to review and officially record all facts which have any immediate bearing upon the case.

The State Hospital for the Insane is situated on the northern boundary of the City of Trenton, about three miles from the center of the city. The main highway divides the property into two portions. To the northeast of the highway are the buildings and grounds of the hospital, consisting of the main asylum building, the new building or annex, engine and boiler houses, and other buildings and residences. To the southwest are situated the laundry and pump house, and some stables. Near the laundry is a spring which was largely responsible for the selection of the present site for the asylum. It is virtually a shallow well, circular in plan, 20 ft. in diameter and about 10 ft. deep from the curb to the bottom. Normally it contains about 5 ft. of water, but this may be drawn down by the removal of a plug at the bottom, when the entire contents can be drawn out upon low land below. This spring is about 300 ft. from the highway. Its curb is 18 ft. and its bottom 28 ft. below the street grade.

Ordinarily water is pumped from this spring by pumps in the adjacent laundry building and also by water power pumps located at the mill below. The force mains from these two sets of pumps join near the spring and pass as a single main across the road and up to the main building. Taps and service pipes are taken off from this main at various places, first in the men's exercise yard, then for the men's wards, then for the central portion of the main building, and finally for the women's wards. For many years this was the sole source of water supply. The supply becoming insufficient was reinforced in 1895 and succeeding years by the addition of three driven wells, 260 ft. deep, located northeast of the main building near the boiler house at the new annex. Water is pumped from these wells directly to the mains and also

to a stand-pipe near by. This stand-pipe is 140 ft. high and 25 ft. in diameter and has a capacity of half a million gallons. The water from these wells is piped to the annex building and also runs into the main from the spring to the main building. By this arrangement if the pumps from the spring are pumping more water than is demanded in the main building, this water can pass to the annex and to the stand-pipe. If the spring supply is insufficient for the needs of the main building, well water would in general be flowing toward that building and no spring water could pass beyond. Moreover, as there is always considerable fluctuation in the demand there will always be near the center of the system a mixed sample of water flowing now one way and now the other, and the nearer any given point is to the spring the more spring water and less well water will be likely to reach that point. The significance of these facts will soon be shown.

The sewer from the annex passes down to the street at such a distance from the spring and water-works as to render its further discussion unnecessary. The sewers from the main building join in a common outfall sewer which originally passed to a septic tank on the canal bank as shown. Later, the city put down an 8-in. tile sewer in the street up to a point somewhat beyond the asylum. The grade being very flat, at the upper end a flush tank was provided but has never been operated. The asylum drain was intercepted by a sludge tank, and from the tank connection was made to the street sewer.

For many years previous to April, 1907, there had been practically no typhoid at the hospital. On April 8 a case was reported in one of the male wards, Ward 4, and there followed on the 11th and 13th two other cases in the same ward, one being that of an attendant. On the 13th there was also a fourth case reported in Ward 12, on another floor. There is nothing to indicate the origin of these cases. The first and second cases were those of patients who had been admitted in February, 1907, and in 1901, respectively, and who had never been outside of the grounds since.

No new case developed for 23 days, except that on May 3 an attendant was taken sick who had been at work for but 2 days and had recently come from Baltimore. On May 6 a case was reported in Ward 7 and on May 12 another in Ward 6. On May 19 the first case appeared in the woman's wing. During June there were four new cases, coming down on the 8th, 24th, 25th and 26th, in four different men's wards, 1, 7, 11 and 4 respectively. During July the epidemic reached its height, with 52 cases in the men's wards and 10 in the women's. All the cases thus far recorded were located in the main asylum building, and the majority of them, 63 out of 74, in the men's wards. During June and July there also occurred 16 other cases located outside of this building. Every one of these persons either worked about the hospital grounds or had the water of the lower spring to drink. One of these cases was that of one of the assistant physicians, living at the annex, but frequently visiting the main building on business. With this exception there were no cases reported from the annex.

The wide distribution of the cases, particularly in the men's wards, showed that this was not a case of personal infection, and the remarkable periodicity noticed in the earlier cases strongly indicated a pollution of the water supply by the institution's sewage. Weight is given to such a theory by a study of the food supply and other possible sources of infection. One half of the milk is produced on the premises and the remainder purchased from one man. The hospital milk was considered superior to the other and was served pro rata among the men's and women's kitchens of both buildings and the central kitchen, where the cooking is done for the staff and certain employees. Each kitchen, therefore, received about half its milk from the asylum dairy and the remainder from the outside. In all other respects also the food furnished the various kitchens was practically identical. Green uncooked vegetables are rarely served. Shellfish are used only for soups. The only commodity which was not distributed equally among the various wards was the water of the suspected spring. This, as has been explained, was furnished quite unmixed to the men's wards, where there were 63 cases among about 400 persons, partially mixed with well water in the women's wards, where there were 11 cases among about 400 persons, while in the annex, with not one case among 400, the water of the spring was probably not served at all. Furthermore, as has been stated, all the 16 outside cases either drank the spring water regularly at home or worked about the hospital grounds or kitchens.

On June 16, an investigation of the sewers showed that the city sewer along the highway was completely choked up and overflowing slightly at one of the manholes. On the following day, June 17, the use of the spring water was discontinued and has been discontinued ever since.

When the writer undertook his part of the investigation, your commission had already been at work several days and had succeeded in demonstrating satisfactorily a direct flow of water between the sewer, which had been again plugged up for the purpose of experiment, and the spring. A quantity of fuchsine, a red aniline dye, had been added to the sewage and a marked pink coloration had appeared later in the spring. It seemed desirable further to investigate the matter and determine if possible whether this passage of water from sewer to spring was one of ordinary percolation through soil or a more rapid flow through fissured rock. At best this would be an undesirable and unsafe condition of affairs, but in the former case it might very readily be that in slowly passing through 300 ft. of soil the sewage would be robbed of all infectious material and rendered innocuous, while in the latter, of course, the pollution of the spring would be inevitable.

It was planned to imitate as far as possible the conditions existing previous to June 17 and then to secure data upon the following points:

(1) The difference in the discharge of the spring when under normal conditions and when the sewer is blocked up and leaking.

(2) The shortest time in which water can pass from the sewer to the spring.

(3) The bacteriological condition of the spring at the conclusion of the above-mentioned experiments.

Meeting the approval of Mr. Herbert of your commission, the plans were immediately put into execution.

(1) AMOUNT OF WATER FLOWING INTO SPRING FROM SEWER.

A weir was constructed at a point just below the outfall of the spring near the canal. The crest of the weir was 1 ft. long and suitable end and bottom contractions were provided. An upright stake driven into the ground at a distance of 2 ft. up-stream from the crest, served as a gage. A hook gage was raised and lowered against the face of this stake to give the elevation. The zero point was determined with a spirit level.

At 10 a. m., July 31, a plug was inserted in the sewer at Manhole 6, so that all the institution's sewage was held above that point. At 11 a. m. the manholes above were nearly filled. At 12 m. water was also turned in from a 3-in. fire hose and the level in the sewer raised nearly to the street grade. The entire flow of sewage from the institution, together with a stream of water from a 3-in. fire hose, was now escaping into the ground from the sewer and continued so to escape for 24 hours during which the experiment was continued. From some rough measurements made in the sludge basin the sewage flow was estimated at 100,000 gals. per day. At 10 a. m., August 1, the plug was removed from the sewer and normal condition restored. During this time the flow of the spring was found to be as follows:

Time.	Flow, gals. per hr.
July 31, 10 a. m.	2,290
11 "	2,290
12 m.	2,290
2 p. m.	2,420
3 "	2,540
4 "	2,580
6 "	2,670
Aug. 1, 7 a. m.	3,040
9 "	3,040
12.45 p. m.	2,580
2 p. m.	2,330

It is thus plainly shown that a stoppage of the sewer and consequent passage of the entire sewage flow into the ground through leaks or a broken pipe gives rise to an increase in the flow of the spring which reached a maximum value of 750 gals. per hour or 18,000 gals. per day, and that the resulting spring water contained therefore about 25% sewage. Weather conditions were such as to have no bearing on these tests.

(2) VELOCITY OF FLOW BETWEEN THE SEWER AND THE SPRING.

To determine this point about 4 ozs. of uranine, a powerful dye of the fluorescein series, was added to the sewage at Manhole 5 [the manhole where the overflow was found on June 16.—Ed.] and well stirred in. This was done at 11.20 a. m. The rocky bottom of the spring was then kept under constant observation for five hours and samples of water drawn from the bottom at those points where the flow was found to be strongest were constantly examined. The first observation of the bottom showed fine streams of pink water coming from the crevasses, this being the remainder of the dye added the day before to the sewer. This red soon cleared away and at 2 p. m., the greenish fluorescence of the uranine was faintly but distinctly detected. This color rose to a maximum at 3 and had all disappeared at 4. The time of passage was therefore determined to be 2.7 hrs.

(3) BACTERIOLOGICAL CONDITION OF THE SPRING WATER.

At four o'clock samples of the water were taken for bacteriological examination. These samples were subjected to the usual tests with the following results:

Total bacteria growing at 37 C.....1,020
Total bacteria growing at 20 C.....5,300
B coli present in 0.01 c. c.

The spring is thus shown to be grossly contaminated. We are now in a position to consider the question at issue, which is, direct connection having been shown between the sewer and the spring, is the flow from the one to the other a case of ordinary percolation, or are there direct passages through fissures in the rocks?

The bacteriological evidence is almost conclusive on this point. Ordinary sand or loam is itself an efficient purifying agent, and the passage of sewage through [illegible] ft. of such material would remove from it the [illegible]y of the bacteria. The fact that the water of the spring contains over 5,000 bacteria per c. c., of which over [illegible] are the typical sewage organism B. coli, is strong evidence for the theory that the passage is though cracks or fissures in the rocks. More conclusive, however, is the hydraulic data. The distance between the sewer and the spring is 300 ft., and under the condition of the experiment there was a difference of 28.5 ft. in head of water level of the sewer to that of the spring. This represents a hydraulic gradient of 9.5%. The rate of flow of water through various kinds of soil and stone has been carefully investigated by Slichter.*

Using the results of this investigation we can determine what kind of soil would be required to allow the quantity of flow observed, namely 2 ft. per min., under a head of 28.5 ft. in 300 ft. A new factor must be taken into account in this calculation, namely the porosity of the soil. A fine porous soil will have the same transmission constant of a coarser but more compact one. It is, therefore, not possible by this method to determine just what kind of a soil we are dealing with, but the general character of the intervening soil or rock can be roughly estimated by a comparison with the conditions given in the following table:

SANDS AND GRAVELS WHICH, UNDER A HEAD OF 28.5 FT. IN 300 FT., WILL ALLOW WATER TO FLOW THROUGH AT A VELOCITY OF 2 FT. PER MIN. (SLICHTER).

Porosity, per cent.	Effective size,* mm.	Discharge, ft.
45	2.8	0.9
40	3.2	0.8
35	3.7	0.7
30	4.5	0.6
25	5.5	0.5

*10% by weight is less in diameter than

So far as velocity is concerned any of the above conditions are in conformity with our results. Let us now consider discharge. In the last column are given the rates of discharge in cu. ft. per min. per sq. ft. of cross section, for the various porosities.

Now, taking the maximum rate of passage of sewage into the spring, 750 gals. per hr., or 1.67 cu. ft. per min., and assuming a height of the water table just above the spring of 5 ft. over the bottom, this gives a flow of .0167 cu. ft. per min. through each of the 100 sq. ft. of cross section at that point.

A study of the table will show that we are not dealing with any of the sands or gravels given, since the corresponding flows per square foot are much greater than the value determined. It will be noticed, also, that as the porosity decreases and the size of material increases, the volume of flow decreases for the same velocity of 2 ft. per min. Now we can imagine this process to continue until we have a very low porosity, a very large size of material and a corresponding low discharge. Such a condition is called for to explain our experimental results. This material is no longer gravel but loose rock, composed of very large pieces with open cracks between them and is well illustrated by the fissured red sandstone of that part of New Jersey. No other kind of material can possibly be made to combine this high velocity and small discharge found experimentally.

It may, therefore, safely be said that not only is there a direct passage of water from the sewer to the spring but that the sewage finds its way not through sand or loam but through crevasses and fissures in the rock; that a considerable amount of sewage, 750 gals. per min., thus reaches the spring in a very short space of time, 2.5 hrs. and that bacteriologically it is comparatively unchanged.

CAUSE OF THE EPIDEMIC OF TYPHOID AT THE HOSPITAL.

With the conditions as above described we have not far to seek for the cause of the epidemic. Of the origin of the first three cases, we have no knowledge. After that the regularity with which each new group of cases appeared and the gradual increase in their number, together with the slow decline of the epidemic about the proper time after cutting out the suspected water, all point conclusively to the water of the spring as the primary and main source of infection.

A careful inspection of the grounds and barns of the hospital wards and kitchens was made. The measures that are being taken to combat the disease seem all that modern science can suggest. The typhoid wards are carefully screened, all cups, dishes and bed pans are thoroughly sterilized, and the dejecta are properly disinfected. The wide distribution of the cases precludes the theory of any local causes of contagion. The dairy barn was, when I saw it, a model of cleanliness, and can safely be disregarded. The distribution of the cases is also against the theory of milk or other food infection as already shown. The water of two of the deep wells was examined bacteriologically and each was found to contain but 3 bacteria per c. c. and no B coli.

*Slichter, C. S., The Rate of Movement of Underground Water. U. S. Geological Survey, Water Supply Paper, No. 140; 1905.

With such a large number of patients of this class, it is hardly possible to prevent more or less direct contagion and in my opinion that is the method by which the latter cases have been transmitted.

If this is the true view of the matter, we may expect to see a speedy diminution of cases, since the possibility of infection decreases with each case removed.

In conclusion, I wish to express my appreciation of the many courtesies received at the hands of Dr. J. C. Felty, Acting Medical Director, and his associates; Doctors W. C. Sandy, F. S. Hammond and W. A. Taylor and of the Warden, Mr. W. P. Hayes. Every facility was given me for getting at the facts in the case and assistance was freely given in every way possible.

Under date of Sept. 11, 1907, Dr. Henry Mitchell, Secretary of the State Board of Health of New Jersey, submitted to that board a report on this outbreak. The report is printed verbatim below, except that repetitions in a closing summary are omitted, and a few new statements in the summary have been inserted [in brackets] in the main part of the report, as follows:

Twenty-eight days have now elapsed since a new case of typhoid fever has been reported from the State Hospital, Trenton, and we may therefore conclude that the epidemic which recently prevailed in that institution has finally ceased.

To briefly review the important facts having relation to this outbreak it may be stated that the first case occurred April 8, 1907, in the person of an inmate of the hospital, located in the west wing of the building, who probably contracted the disease in the city of Trenton [from which he came to the hospital on Feb. 16, 1907]. Subsequent cases occurred in the same wing [the second case being a roommate of the first], and up to Aug. 13 80 cases had appeared in the hospital with 16 deaths. All of these cases were located in the main building of the institution and no cases occurred in the annex, notwithstanding that more than 400 of the inmates of the institution are cared for in that building. Twenty-three employees and other residents in dwellings on the hospital premises were affected with the disease. Investigations concerning the food supply, including milk and water, were negative, except that colon bacilli were found in the water of the spring from which a portion of the water provided for the hospital premises was obtained. Suspicion was at first directed to the water of this spring as the medium through which the infection was spread, but in the light of later developments it now appears improbable that the spring water had any influence whatever in conveying the infection, and we are led to the final conclusion that the disease was transmitted directly from patient to patient and through the agency of utensils and food infected within the building.

This conclusion is justified for the following reasons: (1) The disease first appeared in the west wing of the main building and spread to other inmates in this wing, and as facilities were not provided for the isolation of convalescents the infection was communicable by them to other susceptible inmates. (2) The spoons, forks, cups, etc., used in the dining rooms were washed by the insane inmates, without boiling, and, in the course of the epidemic, every utensil in the building probably became infected, thereby exposing the food which entered the building to infection as soon as it was received.

(3) The filthy habits of many of the insane inmates of the hospital probably caused infected discharges to be generally distributed in the bath room, upon the furniture, doorknobs and other surfaces touched by the hands of the infected persons.

(4) From the west wing the infection was carried to other portions of the main building, but, as above stated, not a single case occurred in the annex, indicating that the infection was not conveyed by milk or water, for the supply of both of these articles was from the same sources for both buildings. The water supply for all of the buildings on the hospital premises was taken from the same piping system, and in the stand-pipe, located near the annex, the water which was pumped into the mains from the spring and from the wells was undoubtedly often thoroughly mixed before distribution to the various branches and service lines.

(5) Inquiry has shown that communication between the infected kitchens of the main building and the dwellings of employees, where cases of typhoid fever occurred, was frequent.

[(6) The disease finally subsided when all susceptible persons who were exposed to the infection had suffered an attack.]

PAY-AS-YOU-ENTER CARS to the number of 300 will be placed in service by the Chicago City Railway Co., in October, according to the "Electrical Review." These cars have a wide rear platform divided into two passageways by a rail in the center. The passageway on the right is intended for passengers boarding and the one on the left for those leaving the car. The front platform may be used for exit only. The rear door closes automatically when the car starts. Slot machines are provided for the collection of fares.

A METHOD OF LAYING VITRIFIED CONDUITS FOR ELECTRICAL CABLES, AND A COLLAPSIBLE CORE FOR FORMING CONDUITS IN CONCRETE WITHOUT THE USE OF VITRIFIED DUCTS.

By F. LAVIS,* M. Am. Soc. C. E.

In connection with the construction of the concrete lining of the Bergen Hill section of the Pennsylvania Railroad's New York tunnels, provision is made for the incorporation of several lines of vitrified conduits as shown partially at A in the accompanying drawing, Fig. 1. For the

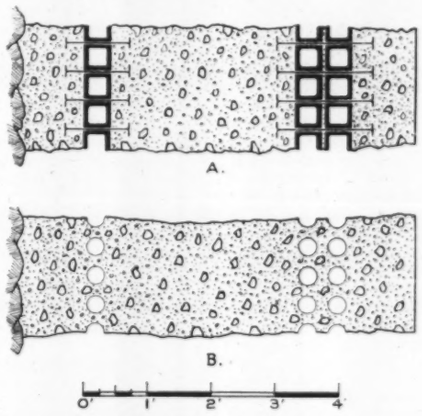


Fig. 1. Vertical Sections Through Side Wall and Bench of Bergen Hill Tunnels, Showing Ducts for Electric Wires, With and Without the Use of Vitrified Conduit.

complete section of tunnel see Engineering News, Oct. 15, 1903, Fig. 20, p. 339. Forked iron bonds are laid between the individual tiers of vitrified ducts, as shown, to bond the several parts of the side walls together; and, in order to obtain as nearly as possible a homogeneous structure, the specifications require that "the concrete be carried up in layers as the conduits are laid." Difficulty was experienced in complying with the specifications in preserving perfect alinement of the ducts so that the interior surface would present no projections to obstruct the passage of the heavy electric cables which are to be placed therein or to injure their coverings in any way.

This difficulty arose not only from the large number of joints (the ducts are in sections 18 ins. long) and the variations in thickness of the sides of the ducts, but also from the virtual impossibility of avoiding throwing the ducts out of line by the movement of the forked bonds when placing the concrete. In attempting to build the ducts and concrete up together, the process of depositing the concrete tended to throw the ducts considerably out of line. If the concrete was very wet it was not stiff enough to hold the ducts securely in line, and if dry the necessary ramming caused trouble.

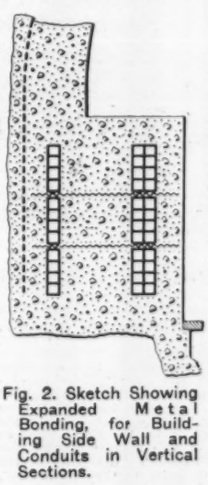


Fig. 2. Sketch Showing Expanded Metal Bonding, for Building Side Wall and Conduits in Vertical Sections.

On account of the difficulties experienced, permission was given on one section of the work to try other methods of building the walls. The experiment was therefore tried of building the wall in five sections. The concrete between the rock side of the tunnel and the first line of ducts was placed first, a form, of course, being necessary for this; then, after the forms had been removed, the first line of ducts was laid up against the surface thus formed; after this, the second or middle section of concrete was built, a second form being necessary for this; the form being removed, the outer two lines of ducts were laid; and finally, the outer section of wall was built, again with use of a form. As it was not well possible to use the forked bonds in this method of construction, advantage was taken of a clause in the specifications which permitted the substitution of expanded metal, one sheet being inserted between the fourth and fifth layers of ducts and another between the eighth and ninth, as shown in the sketch, Fig. 2. However, even with this modification the method involved a heavy expense, not only on account of the cost of building the three sets of forms necessary, but also because of the considerable extra cost of depositing the concrete produced by the interference of the expanded metal. The delay incident to waiting for the different sections of concrete to set before removing the forms was a further bad feature of the method.

In an endeavor to avoid these disadvantages and yet meet the clause of the specifications which required building up the concrete and the ducts together, King, Rice & Ganey, who have the subcontract for the construction of the lining of the Bergen Hill tunnels under William Bradley, the general contractor for that section, devised the collapsible wooden mandrel, shown in Fig. 3, for holding the ducts in accurate position and alinement during the concreting. As their plans provided for the construction of the tunnel lining in 28-ft. lengths, the mandrels were made 30 ft. long. In this length are distributed about six projecting wedges, separating the two halves of the mandrel; the slope of these wedges is purposely made quite steep, so that a comparatively small longitudinal movement is sufficient to collapse the forms, yet flat enough to bind sufficiently to hold the ducts firmly and stiffly.

In carrying out this method of construction, the concrete was first laid the full width of the wall up to the lower tier of ducts; the first rows of ducts were then carefully laid and the mandrels inserted and expanded, thus holding the ducts completely rigid and with the interior joints necessarily all flush; the concrete was then laid for the full width of the wall up to the height of the top of that layer of ducts, the forked bonds placed in position, more ducts laid, and so on to the top. The length of the mandrel permitted its insertion for about one foot into the preceding finished work, the forward end being left projecting an equal amount. Sufficient mandrels were provided so that there was one for each duct. They were left in place until the concrete had set, being taken out at the time when the regular concrete forms were removed.

In following out this idea it occurred to Messrs. Rice and King that on the same principle as this mandrel a collapsible core could be made which would leave a round hole in the concrete, as shown at B, Fig. 1, and thus avoid altogether the use of the vitrified ducts and the forked bonds, the whole structure being a homogeneous mass of concrete with simply the holes for the cables left in it. A cross-section of this form is shown in Fig. 4. An experimental section 30 ft. in length was built,

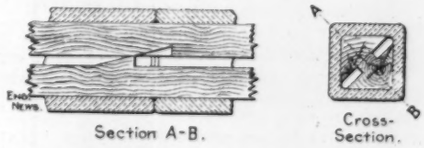


Fig. 3. Expanding Mandrel for Square Duct.

containing three holes, as shown in the accompanying photographs, Figs. 5, 6 and 7. When the cores were withdrawn, after the concrete had set, three perfectly smooth and regular circular holes 3½ ins. in diameter were found. In building this section the concrete was deposited up to a point slightly (¼ to ½ in.) above the proposed bottom of the hole and the expanded core laid thereon and settled into place; the concrete was then laid around the core and carefully tamped, and then carried up to a point slightly above the second hole and the second core set, and so on. This method of procedure was found to be much

*Resident Engineer, Bergen Hill Tunnels, Pennsylvania Tunnel & Terminal Railroad Company [New York Extension of the Pennsylvania R. R.].

more satisfactory in every way than any which involved setting all the forms before the concrete was placed; it absolutely prevented any sagging of the cores and permitted the concrete to be placed carefully and tamped around the holes, with nothing to interfere with the rapid prosecution of the work.

The views Figs. 5 and 6 show the construction of the experimental section with the middle core or mandrel in place ready for the placing of the second layer of concrete. Fig. 7 shows the section after the forms had been taken down and the mandrels withdrawn from the holes; one man-

Fig. 4. Collapsible Core for Molding Circular Ducts in Concrete Without Tile.

drel may be seen lying on top of the concrete, expanded, and two on the ground alongside, collapsed. It may be noted that a section 30 ft. long with a single hole had previously been made and afterward broken up, showing a perfectly smooth interior surface throughout the length of the hole. No difficulty whatever was experienced in withdrawing the cores after they had been collapsed.

The work in the Bergen Hill tunnels is, however, being done with the use of vitrified ducts, as first described.

These ideas, which have been covered by patents, will undoubtedly come into extensive use, both where vitrified conduits are necessary on account of the use of high-tension currents and where conduits may by the use of such cores be dispensed with altogether, as in cases where low-tension wires and telegraph or telephone cables are to be placed.

This work is part of the North River Division of the Pennsylvania Railroad tunnels and is under the direction of Mr. Charles M. Jacobs, Chief Engineer.

FOUR CENTRIFUGAL PUMPS BUILT OF ACID-RESisting bronze are to be installed at the Bellevue colliery of the Delaware, Lackawanna & Western R. R., for mine drainage. The pumps are of the single-stage, electrically-driven, centrifugal type; three have a capacity of 250 gals. per min. each, against a head of 100 ft., and are direct-driven by 15-HP., D. C. motors; the fourth has a capacity of 700 gals. per min. against a head of 100 ft., and is direct-driven by a 30-HP., D. C. motor. Both the pumps and motors were built by the Allis-Chalmers Co., of Milwaukee.

ENGINEERS' CONTRACTS AND SPECIFICATIONS FROM A CONTRACTOR'S POINT OF VIEW.*

By JAMES W. ROLLINS, JR.,† M. Am. Soc. C. E.

A contractor must base his figures on definite information, or else make some wild bid, the degree of wildness being in accord with the risks to be run. On some contracts this element of uncertainty *must* be large, and the writer believes this to be the only class of work properly done on a percentage (or cost plus) basis. But also in very many other contracts there are many uncertainties injected, some dependent on the wording of certain clauses, from which the contractor's only hope of salvation is the fair-mindedness of the engineers; and here the man who knows the engineer and his way of handling work has the advantage over the stranger.

For instance, quoting from an existing contract:

> Excavations shall be made of dimensions indicated upon the plans, where dimensions are given, except as otherwise directed.
> Piles shall be driven not below elevation 102, and shall be cut off at these levels unless otherwise directed.

In the first case quoted, plans showed excavation to — 28, and then comes in the "otherwise directed" clause by which excavation could be made to — 50 if desired, at no extra price to contractor. Similarly, under the pile clause, piles may be cut off anywhere.

Referring to another contract, for a dam,

> if excavation is required below a certain grade, a special price is to be paid for such work.

Which of these clauses do you think the most fair, and can you suggest any reason for putting such uncertainties into a contract, without provision for a just and proper payment for the work done?

The very customary clause in a contract, which makes the chief engineer the sole judge of everything, the quality of work, the amount done, and the value of it, appears to us to be a most unjust clause. The need of an arbitrator does not come until parties in interest have disagreed, and then under this clause one of them settles it for good and all. It takes a true and good man to be entirely just in settling a row in which he has been a participant, and may have even been knocked out in the first round. It is not uncommon to hear of engineers who will "get even" with contractors. A more just and proper clause is such a one as this, which is now quite common with engineers, and is a standard clause in architects' contracts:

> Should any dispute arise concerning the true construction of the plans or drawings and specifications hereinafter mentioned, or any part of either, the same shall be decided by the said engineers, and their decision shall be final; but should any other difference arise between the parties of the first and second parts, the same shall be submitted to the arbitration of two competent and disinterested persons, one to be named by the party of the first part, and the other by the party of the second part, which two in case they cannot agree may choose an umpire; and the decision of the arbitrator, or the umpire, shall be binding and conclusive on all the parties hereto.

The absolute disclaimer of any responsibility for the accuracy of borings seems unjust. Many of our large water jobs give us extensive and detailed plans of borings, and contractors must necessarily base their figures on them. If these borings prove to be wrong, and the contractor suffers thereby, why should not this be borne by the owners? It is not a contingency figured on by the contractor, and in all faith and justice he should not suffer. He has to take chances on the winds and the floods, the frosts and the thaws, the acts of God and the perversity of man, of quicksand and other classes of excavation; so why should be added to all these the errors of "borists," and they make many?

When we drive piles through 20 ft. of "solid rock," or 50 ft. through "sand and gravel, very hard," and have figured on short piles, we have a spirit of kick in us, and think someone should pay the price. You engineers all say, "We gave you the results of the borings out of the spirit of our hearts to help you, and we thought them correct; so you shouldn't look a gift horse in the mouth and complain, but should take your medicine." Here the mutuality comes in; the basis of the contract was wrong. It seems to me it is one of the items of common misunderstanding, which might be eliminated.

Every contract to-day affords ample protection against unjust claims for extra work; most engineers check up all costs of such, and by the contract, bills for same must be rendered monthly; so how is it possible for any great "graft" to come in with such claims?

Clauses in contracts which in any way give the engineer control over the methods to be used to do the work, or those which throw the responsibility of the work designed by the engineer on to the contractor, are great sources of trouble. This means divided responsibility, and this, as sure as fate, *trouble*; for no two men, especially a contractor and an engineer, can exactly agree upon methods of doing work.

We are to-day at work on structures every detail of which was designed by engineers; they have reserved the right to tell us in detail exactly how to do everything connected with it; and on the end of the contract clause are the words:

> the contractor shall assume all responsibilities in the work, and for the stability of the structure.

What do you think of that? But one thought can come to you, and that is, we must be idiots to sign any such contract. In a great measure we are idiots, but we have to run chances other than acts of God, etc., and that is, I am glad to say, one chance we rarely lose, that the engineers are fair and honorable men in settling matters of this kind.

You all know of the trouble from such a clause in the Charlestown Dry Dock, where the contractor was to submit a plan for cofferdam satisfactory to the engineer. He submitted one, of the most common and efficient type, but it was not approved. After many delays a plan was approved, the dam was built and *failed*, and there are now pending claims of hundreds of thousands of dollars against the Government on account of this failure. Personally, the writer fails to see why any engineer wants to assume the responsibilities of others, and, where his clients are protected by suitable bonds, why he doesn't let the contractor go ahead and make his own plans and work out his own salvation, or damnation, as he will. A clause from a Boston Transit Commission contract bears on this subject:

> But neither the Commission, nor any member of it, nor the engineer, etc., shall have any control or direction over the progress of the work, nor any control or superintendence over the apparatus, ways, works, machinery or plant; the sole responsibility for the proper handling of which, as well as for the safe and proper conduct of the work, resting solely with the contractor.

Fig. 5.

Fig. 6.

Fig. 7.

FIGS. 5, 6 AND 7. EXPERIMENTAL SECTION OF CONCRETE WITH THREE DUCTS MOLDED BY USE OF COLLAPSIBLE CORE.

*Abstract of a paper read before the Boston Society of Civil Engineers on Feb. 20, 1907, followed by extracts from the discussion of the paper. Paper and discussion are reprinted in full in the "Journal of the Association of Engineering Societies," July, 1907.

†President of Holbrook, Cabot & Rollins Co., Contractors, 922 Beacon Bldg., Boston, Mass.

Inasmuch as this commission's work was done under very expensive buildings and the city streets, where great trouble, loss of property and life, were possible, it seems to me that the commission showed its good sense by keeping clear of the "ways and means," and the temporary work, and letting the contractor do the work his own way and assume the responsibility.

Another clause in many contracts: That the engineers may shut down the work at any time and for any reason and the contractor has no redress. This clause must have had its origin in old railroad construction, where questions of right-of-way or of alinement were always uncertain, and it has been perpetuated to-day to our great sorrow and many times our loss.

To insure the completion on time the lawyers—I don't think the engineers ever coined any such expressions—meekly say, "Time is of the essence of this contract, and you shall pay $100 a day, not as a penalty, but as liquidated damages." We know what liquids are and what damages may be, but we haven't been able to find the difference to our pocketbooks between "liquidated damages" and a "penalty." Hence the proposition: We must finish on time or pay $100 a day, but the other party can hold us up for any length of time and pay us nothing for the loss to us for this delay. We build special plants to do the work, get men trained to do the work properly and well; then comes the order to stop, shut down the plant and discharge the men. The plant cannot be moved, but must stay idle, new men must be trained over again; if work is done on a rising market, if labor demands more pay, we pay it, and all this loss comes on the contractor. Why should it? We didn't figure on it.

Not content with the general obnoxious and unjust conditions mentioned, which are very common in contracts, often special provisions are made, which put most extraordinary powers in the hands of the engineers, and, as they are hastily read over by the contractor, do not mean much. For example:

> The said contractors hereby declare and agree that they shall be accountable for the full performance of this contract, and by the signing hereof admit that the said plans, elevations, sections, specifications and parts before referred to are sufficient for their intended purpose of doing the said work, and that the work can be successfully executed in accordance therewith without any additional or extra work other than that set forth thereby or necessarily inferred to be done from the general nature and tendency of the plans, drawings and specifications aforesaid upon a fair and liberal construction thereof.

This innocent clause cost us on one contract $10,000. We took a contract to rebuild two abutments and one pier for a river bridge. The plans, not very complete, showed the new abutments to be about 18 ins. clear behind the old work, which had to remain in place until new work was built. These abutments were 36 ft. high; and when excavation got down to water level it was found that the old work was thicker than the plan showed, and left no room to put in cofferdam between it and the new work. It cost $10,000 to get the lower 4 ft. of these foundations, owing to the impossibility of making the cofferdams tight. We protested to the engineer on the first abutment, but to no avail; asked that another abutment be fudged back 2 ft., an easy matter; but no change was allowed. Work was finally completed and demand made for extra pay for work, on account of errors in plans; was not granted, and was then left to be arbitrated as contract provided, the chief engineer meanwhile insisting that his company or his office was not at fault, or liable; and this clause was then brought out by our own lawyers, and we were advised that we had assumed all responsibility in the matter and had agreed that the plans were sufficient to do the work called for, with no extras.

Later, on this same contract, we deposited concrete under water, and after a month it proved worthless, and examination showed that the river water was polluted to such an extent as to destroy the cement; to do the work then required a cofferdam to be driven for pier in the middle of the river, the water pumped out and masonry substituted for concrete. Again was this clause brought to our attention and our counsel advised it was very doubtful whether we could recover in court, even though the contract in a way required an impossibility.

It is a general impression among engineers that clauses requiring impossibilities are null and void and that a court would not recognize them; but the law on the case is very deficient and the cases tried in this country very limited.

In a recent opinion on the question of executing an impossibility, the Court stated that the delay was one due to the contractor's error of judgment, and that there appeared to be no ground upon which he could ask to be excused from the consequences of his own mistake. The Court cited with approval the rule expressed in the case of Chicago, etc., Railway Company v. Hoyt (149 U. S., p. 14), which is as follows:

> There can be no question that a party may, by an absolute contract, bind himself or itself to perform things which subsequently become impossible, or pay damages for the non-performance, and such construction is to be put on an unqualified undertaking where the event which caused the impossibility might have been anticipated and guarded against in the contract, or where the impossibility arises from the act or default of the promisor. But where the event is of such a character that it cannot be reasonably supposed to have been in the contemplation of the contracting parties when the contract was made, they will not be held bound by general words which, though large enough to include, were not used with reference to the possibility of the particular contingency which afterwards happens.

In another case of work we did, this application of an impossibility clause came in as follows: Plans showed 6-in. hard pine sheeting driven to a depth of — 20, and specifications said simply, "Sheet piling shall be driven as shown on plans"; and no borings or samples were shown, and no mention made of material or the possibility of hard driving, though the ground showed sand. Before we got ready to do our work other contractors had driven sheeting of same kind for a trench, and their work, though done under much easier conditions (i. e., with sheeting driven only a little ahead of excavation in trench), showed the timber to be seriously crippled by the gravel stratum into which it was driven. Our line of sheeting was to act as a permanent bulkhead, and to be of any value should be put into place without crippling. We tried all sorts of ways to get the sticks down, with a jet and otherwise, and finally gave up the attempt on the assurance of the engineer in charge that, in his opinion, we could not drive it in a way satisfactory to him. We took up the impossibility plea and were gently advised by the owners that in the opinion of their lawyers we agreed to drive that sheeting as shown on plan, and that we must do this even though the material was rock and we had to bore holes to put the sheeting into. We finally dredged the gravel out, drove our sheeting, backfilled it, and finished the work, the company paying us, I think, cost of dredging.

But these cases put all the burden of unforeseen things on the poor contractor, and when trouble comes, the engineers refer the matter to the lawyers and they interpret the law, not by right or justice, but the strict legal meaning of the contract, and I venture to say that not a single contract is made to-day on large works which does not give the engineer power enough to put the contractor into bankruptcy by such clauses as I have been quoting. All this is unnecessary. Every contract has a provision for extra work and for the filing of all claims for damages, change of plans, etc., with engineer once a month, and the right of engineer to see all papers connected with these claims. They cannot be collected by demand of contractor, but only at last resort by a court of law, which in our free country is the court of last resort to all injured souls. So why should not contracts be made which give the contractor some rights to a settlement other than by the man he cannot agree with, by some disinterested person who can do justice, having some regard to the old principle of man-to-man settlement?

Every unnecessary or unfair clause in a specification has its part in limiting competition and in lowering the standard of honesty among contractors. A clause that may be used as a club can be avoided in one of two ways, either by not bidding on work governed by the clause, or by using "graft" to insure that it shall be a dead letter.

Many contracts to-day show the improvements which we wish to become more general, and eliminate the clause which makes the engineer the final judge of all things, substituting settlement of disputes by arbitration. This is a great step forward, and we trust that the other few clauses which make trouble, when trouble comes, may be eliminated.

The courts now lean towards the "intent" of the parties making the contract, the "mutual understanding," between the contracting parties. This means that the contractor shall do what the plans and specifications call for in a fair and just interpretation and under the conditions which at the time of making the contract seem to be most probable, and such understandings must bar out the particularly objectionable clauses as follows:

(1) Disclaiming responsibility for soundings or other information as to the character of the work.

(2) The insertion of clauses which make any contractor's estimates worthless by adding, "or as otherwise directed."

(3) Making the contractor responsible for work for which engineers make the plans or require their approval to any made by contractor, and where engineers reserve the right to entirely control the manner and means of construction.

(4) Holding contractor responsible for work which has passed inspection or has been done under direction of engineer, or his agent, or inspector, unless fraud can be proved.

(5) Making the engineer the sole referee in setting all claims.

(6) The right to stop work, or any part of it, if for the interests of the company so to do, without allowing the contractor anything for the loss such action might bring to him.

When these clauses are eliminated and others substituted which give the contractor the benefit of the "intent" of the contract, and which will insure a settlement on that basis by disinterested parties, then comes the day of freedom for contractors.

The troubles arising on account of specifications are due about equally to the text as written and to the interpretation of the text when written.

Engineering is an exact science, and a specification must be explicit and cannot use the word "about"; the main point in the interpretation is how much variation from the exact figures given can be allowed. We cannot get perfection; it is useless to try to get that in this world, and as its substitute, we must get as close as possible, and as practicable. It is a question of practicability versus perfection, and the man who has the good judgment to get the best practicable is the successful man.

Engineers often put common words into a specification, which words have a common meaning to us, and then, when we get to work, bring out their interpretation of those common words. For instance, "Coarse, sharp sand shall be used." Does this mean that 27% of this sand shall pass a 200 sieve, or that 86% shall pass a 27 sieve? We never did nor do we ever hope to know. If size of sand is to be tested by a sieve test, specification should so state.

> Cement shall be of a well-established brand, shall be subject to inspection and rigorous tests of such character as engineer shall determine.

Does this mean, in the entire absence of any detailed chemical composition, that we shall furnish cement having abnormal proportions of sulphuric acid, magnesium and of lime, either high or low?

> A pile shall be at least 6 ins. at tip, and not less than 30 ft. long.

Does this mean that the minimum of 6 ins. for tip and 30 ft. for length shall be allowed to be used, and as much larger tips or longer length as the engineer may require, or does it mean no pile can be required driven with a larger tip than 6 ins. and a longer length than 30 ft.?

> The stone used in the work shall be from one quarry, shall show no streaks or sap or other imperfections and shall be uniform in color.

Does this mean that each single stone shall show no sap or streaks and shall be uniform in color, or does it mean that all the stone in the work shall be of the same color, with no streaks or sap?

> The contractor will be required to embed in or attach to the masonry sills and bearing timbers and such other timber as may be required.

Definition of timber, according to dictionary: "Wood fit for building; a piece of wood squared or sawed." Can you conceive of a frame, with bolts and bearings, fitted for gates, for door frames, window frames (and I don't know but mosquito frames will come later) being considered as timber, to be set at a given price per thousand?

Should not specifications be explicit on these points, that a contractor can know on just what he is bidding?

The engineer should know what he wants when he writes his specification, and should state it, and not come around after the contract is signed, all material contracted for, and then bring out some special tests wanted, some wire factory work, or some special interpretations which the contractor never heard of.

Very much trouble comes from masonry inspection, the quality of the cutting, the size of the joints, plug holes, etc. Regarding the matter of masonry joints, I want to say a word. Early in our engineering days, we were talking with a stone man about good joints, and he told this incident: He cut some large stone for a government job for engine beds, and the specifications called for peen-hammered beds and joints. He made them, work was accepted and built. In a very short time, under the vibrations of the engines, the joints parted. The stones were taken out, "plugged" good and hard, and put back, and stood the vibration without trouble. At Portland, Me., is another government job, a small arch, where the joint next the skew back is about ¼-in. The whole length of the arch stone has split off, owing to thin joint. To-day there is another arch, the longest railroad span in the country, standing without trouble under a terrific load, with mortar joints which will average 2 ins. thick.

We give these facts to show the trouble which has come to fine small joints, and also to show how much a large joint, built solid, can stand. But stone is hard and tough, and the men who cut it are equally hard and tough, so that much trouble comes to work where the stones are all "specials," and some one is plugged too hard, cut slack or is off-color, and the whole job has to shut down to wait for a new stone from a quarry a hundred miles away. We can't ask you to discharge your inspectors and take everything that comes, but we can and do ask for reasonable inspection, for a consideration of the means through which material is obtained and manufactured; that when you want a monument you ought to have it as good and true as man can make it; but when work goes out of sight, under ground or under the sea, a pea-green stone is as good as cadet gray, and a ⅞-in. joint as good as a ⅝-in. Generally speaking, we do not cut or furnish the stone, and the loss of a condemned stone doesn't fall on us, but the spirit of getting a "pound of flesh" is what makes the trouble, and extends from the contractor, through the superintendent, foreman, masons and even to the water boy.

If a contractor bidding on public works to-day ever tries to figure on all the chances which may come up, he never will get any contracts. He has to run the risk, to trust that some things will come his way, enough to balance the things that go against him. He doesn't want to be always kicking, making claims for extras, for

small things, in the hope that the engineer will give him the benefit in doubtful cases, and such advantages as the work may offer, enough to offset his little extras. But when he doesn't get any of these benefits, especially if he feels that the engineer is willfully withholding them, is compelling him to do the work to the exact letter of the specifications, where such work is of no value to any one, when he is, in the common term of the profession, "getting roasted," then comes trouble, claims for extras, kicks and general eruptions.

Do you know what the lack of a square deal means? That the other fellow denied this now great American right has it in his heart to get even with the man who denies it to him, and it takes a good Christian and a square man to curb that impulse.

To give and to take, to do justice on the one hand, and good, honest work on the other, and then settle the differences, man to man. Then lawyers will go out of our lives, courts be left for the Boston Elevated cases, and then will come the day of good fellowship and regard which should exist between the creators and makers of this modern world, the engineers and contractors.

The following quotations are taken from a personal letter of Mr. Seth Perkins, civil and contracting engineer, of Boston:

The traditional and proper function of an engineer as related to contracts is to act as an arbitrator between two parties to a contract, and as all contracts are presumed to be conceived in fairness every impulse of an engineer should be to measure the fair rights of each party in having the work properly carried out.

Theoretically, works are designed and specifications and plans are drawn to give true and graphic exhibits for the purpose of obtaining competitive bids.

Practically, engineering is not an exact science, nor can it be on account of the many uncertainties bound to exist, which only develop into certainties as the work progresses. The engineer animated by an idea of fairness could draw his specifications in such a way as to definitely specify known factors, and provide for the unforeseen conditions in a way which would insure justice to both parties. But this never will be done while engineers work from fixed clauses probably dictated by a mind trained in legal thought and without the elasticity which is the outgrowth of engineering experience. I feel in many ways that the engineering profession has been made subservient to the legal, and I think to its detriment. There is no profession in which the training tends so much to analysis and by force to synthesis. Then why should we allow the legal profession to dictate arbitrary clauses in specifications which are in conflict with our judgment and bound to place us in a false light? The only use to which I have been able to put the legal profession is to unravel snarls of their own making, and then they had to call for expert knowledge where the knots were too tightly drawn. I suppose the burden of your argument will be objections to the arbitrary clauses in contracts and I think they should be attacked. For when controversy arises, as is often the case, where unforeseen conditions come up that have not been made the subject of particular specifications, the usual result is to fall back on general clauses which are generally arbitrary, and if the controversy assumes the proportion of litigation the interpretation of these clauses is left to a Court having no training which would entitle him to judge what was the original intent of the engineer responsible for the specifications or the spirit they intended to convey.

Discussion.

H. H. CARTER.*—Two or three years ago I took considerable interest in the matter of Mr. Rollins' paper. I appeared before a legislative committee for two successive years endeavoring to have a law passed making it obligatory for the commonwealth, cities and towns to introduce into their contracts an arbitration clause instead of the present clause making the engineer sole judge of everything.

The matter has largely gone out of my mind at the present time. I will, however, look through a Transit Commission contract and mention a few points.

(1) Contractors object to the present clause making the engineer a referee to decide all questions relative to the *fulfillment* of the contract, and that his estimates and decisions shall be final and conclusive. It seems to me while the engineer is properly made the judge as to the fitness of materials, he certainly should not be referee to decide all questions relative to the *fulfillment* of the contract, and that questions of that sort should be decided by three parties, one to be appointed by the commission, one by the contractor, and these two to select a third. This provision you will find in force in the contracts drawn up by the Master Builders' Association.

(2) Contractors object to the clause stating that "if delay occurs on the part of the commission in furnishing the material, or if the contractor is delayed by other cause which is not his fault, the contractor shall have no damages on that account," etc. This is manifestly unfair.

(3) Some contracts contain a provision that in figuring the cost of extra work the contractor shall not be allowed to have superintendence, liability insurance, etc., figured in. As these are matters which all enter into the expense of the work, they should be taken into account in figuring the expense of extra work. Liability insurance in some instances amounts to 9% of the pay-roll, and there is no reason to leave it out as an item of expense in contract work.

(4) I think the time has now come when engineers should entirely revise the present form of contract and specifications and draw them up in a spirit of fairness to both contracting parties. The present form of contract arises from one engineer after another, assisted from time to time by a petty lawyer, endeavoring to alter the previous form of contract and introduce some ironclad clause, still further tying up the contractor body and soul and throwing on him the risk and expense of work which justly the other party to the contract should bear.

(5) All clauses requiring the contractor to do certain work at his own expense, "unless otherwise directed," should be done away with. Such clauses throw doubt on the good faith of the engineer and leave the contractor in doubt as to how he should make his figures, and also give him the idea that some other favored contractor knows in advance how the engineer will direct.

(6) All clauses should be done away with giving the right to the engineer to deprive the contractor of compensation for necessary work done under the contract. For instance, a recent sewer contract contains provision for 5-in. tongued and grooved sheeting driven below grade. The engineer has the right to order it taken out on the completion of the work if he so elects, in which case the contractor receives no compensation for furnishing and driving it. If it is left in, however, he receives $70 per M. ft. B. M. This item alone on the particular contract referred to left the contractor in doubt as to whether or not he would receive any compensation for $40,000 worth of prescribed work.

(7) All clauses requiring the contractor to do work at his own expense when such work is not contemplated by the plans and specifications should be altered, and if such unexpected work is necessary, the clause should read that such work is to be done at the expense of the other party to the contract.

Mr. Rollins has put the whole matter of these contracts and specifications in a nutshell when he uses the term "a square deal." Unfortunately, the training which some engineers go through, unless they are big broad-gage men, seems to shrink them up into the class that looks on the cent as the ordinary man looks on the dollar.

C. G. CRAIB.—To show how this clause in the specifications, giving so much power to the engineers, works to the detriment of the contractor in an unfair manner, I will speak of the contract that I had in a city not far from Boston. We had a trench, not very deep, but it seemed to me that you'd stand about as much chance to put a pump on a raft in Boston harbor and try to pump the water down as to pump that trench. After opening a large section of it, it was necessary to have a large number of pumps, and it was thought best to move those pumps on Sunday. The next Saturday night at 12 o'clock we began making the change, so that the work would be in a condition for digging the next Monday morning. But under this general clause in the specifications the engineer took it upon himself to come out Sunday morning in the midst of the operations and stop the work simply because it was being done on Sunday. There is no law I know of, as this was so far removed from dwellings as not to be a nuisance to any person, under which he could do that except by placing a very broad construction, from his point of view, on that clause in the specifications giving him the power to regulate the contractor's work. There was a case where it worked very much to the disadvantage of the contractor. Another case occurs to me, in a town which has since become a city, in which the pumping was stopped in the middle of the day on Sunday by the engineer because there was an objection made by people who attended the church close by. I shouldn't have thought very much of that if I hadn't known that a number of the people who made the complaint were interested with Jernigan in trying to extract gold from sea water and to sell stock for that undertaking. I thought that their religious scruples were rather far-fetched in my case, but of course they had to act through the engineer, which they did.

In another case I contracted to lay a 20-in. pipe in a trench, and the engineer specified how the joints should be made. A string of jute was to be inserted in each joint. The pipe was furnished under another contract by the town, and I think that out of 550 ft. we found four pieces that would go together without chipping. Still the engineer insisted that we should chip off enough to get the jute in, because the contract specifications required that we should do that. Those little things form the reason why contractors and engineers are at odds at times. It is not the general specifications. I have read through carefully during the past few days several sets of specifications, and I cannot find a word anywhere that I'd be willing to cut out, looking at it from the point of view of the citizen.

The general objection to general specifications is not that it is not wise to have a good strong set of specifications, so that the engineer can have control of the work, but it is that some engineers take advantage of that and neglect to give the contractor's side of the question proper consideration. At this time, when so many engineers have taken up the contracting business, some arrangement could be made by which a general form of specifications might be recommended that would be more in a spirit of fairness to the contractor and in justice to both parties to a contract.

C. R. GOW.*—It is probably no exaggeration to say that the disposition to, in a sense, take advantage of the contractor by the shrewd wording of the text and skillful evasion of responsibility has been the cause of more dishonesty on the part of contractors than any other single reason.

How often we have heard our engineer friends condemn, with righteous indignation, the habit of the contractor who studies the contract and specification for some loophole or omission through which he may legitimately claim additional compensation or relief from onerous requirements. How often, also, have we seen the same engineer, when he discovers that he has failed to foresee and provide for some contingency which has arisen, take refuge behind some blanket clause, which never contemplated this particular contingency when it was written. Are not the two traits identical? The contractor seeks to safeguard his pocketbook and the engineer his reputation as a farseeing and shrewd official.

I agree with Mr. Rollins that the greatest absurdity that exists in present-day contracts, from the standpoint of fair play, is the clause making the engineer sole arbitrator in cases of dispute. It is inconceivable to me that any man who must of necessity be a party to the dispute, and having made up his mind in advance, could or should desire to exercise the judicial function of a referee in deciding whether he or the other party is right. Not only are we obliged to accept the engineer as referee, but in addition must agree that our methods, men and materials will be acceptable to him, and that he shall finally decide whether or not we are entitled to any compensation, and, if so, what amount. Can you not imagine that under these conditions the personality of the engineer will enter largely into our estimates of costs? Some engineers we do not care to work for under any circumstances. Some require that we add a large percentage to our figures to provide for their close and arbitrary dealings and interpretations, while still others are known to us as fair and liberal-minded men with whom we feel justified in taking chances and have confidence in obtaining a square deal.

As to the specifying by the engineer of the detailed methods of operations, my opinion is entirely in accord with that of Mr. Rollins. I was once consulted by a prominent engineer as to the proper procedure in a matter of which this engineer had no previous experience. He requested my opinion on account of certain successes I had made in the class of work under discussion. Subsequently he embodied in his specification the general method outlined by me, but in addition also his own conception of the detailed manner of carrying on the work, a conception which, by the way, was erroneous. It so happened that I was the successful bidder, and much to my surprise and disgust was obliged to follow out his ideas in spite of my protest, with extremely unsatisfactory results both to the engineer and to myself.

Another habit which is growing among contract writers is that of specifying prices for certain items. On a certain contract executed by our firm a price of $13 per thousand was stipulated for sheeting left in place. No estimate was given of the probable quantity to be used, but it seemed likely that the amount would be inconsiderable. On the contrary, there were 150,000 board feet so left in place, costing us for the lumber alone $22 per thousand, and representing a loss to us of $1,350 outside the labor cost. A protest to the engineer against this arbitrary allowance on so large an amount was met by the argument that we should have taken it into account in making up our bid; but how could it be considered in the bid when the amount to be used was absolutely unknown? We were then reminded by him that we should not have bid on the work if we did not like the specification. This argument is in line with that of the railroad official who tells you that you do not have to ride on the cars if you do not like the service; you can get an automobile or walk.

There is a very general tendency among engineers, and I can refer back to the time when as an engineer I did the same thing, to make certain requirements simply because they are called for by the specification, and regardless of whether or not they are necessary in the sense that the specification intended. Undoubtedly every clause contained in a specification had originally some reason, either good or bad, for its existence. Too often, however, many of these clauses are enforced against the contractor without any reason. I was at one time prevented from using second-hand lumber in foundation platform, not that the quality of the lumber was in question, not that it would not fulfill the function as well as new lumber, but merely, as the engineer explained, because the price stipulated for this item contemplated the use of new lumber. On another occasion a contract for a certain state commission called for the use of several thousand barrels of cement of a brand acceptable to the engineer. A canvass of prices obtained from the cement dealers showed one brand to be quoted 30 cts. less per barrel than the others. Upon submitting the matter to the engineer I was informed that this brand would not be accepted, and the higher price was therefore paid. A few weeks later I learned that this same engineer had

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contracted for a large order of the cheaper cement for use in day work being done by the same commission after bids for the work had been rejected as being too high. The same specification for cement had previously been used by the bidders on this work as was applied to my work. On the same contract I was required by the engineer to suspend work until heating arrangements satisfactory to him were installed, while a personal visit by me nearly a month later to the day work referred to showed absolutely no attempt at heating or heating apparatus.

Still another matter which oftentimes causes unnecessary annoyance and hardship to the contractor is the tendency of engineers to retain all of the contractor's money that their consciences will allow. The general rule appears to be, "In cases of doubt, hold back enough." If engineers were obliged to pay 6% interest on all reserves, it is safe to assume that they would soon experience a change of heart.

Practically all of the evils referred to are attributable to the blanket clauses contained in our contracts. There is undoubtedly a necessity for the insertion of certain clauses of a general nature which cover certain specific classes of work. These are understood in advance by the contractor, are accepted in their general sense and provided for in his estimates. It would seem, however, that the English language is sufficient to fully cover and clearly explain every individual thing that the contract is intended to cover, the general method of procedure expected and the prices for payment of same, without resorting to vague and indefinite blanket clauses which mean nothing to us when figuring the job, but which may mean thousands of dollars before the work is finished. The presence of such clauses in a contract may be accepted as a confession on the part of the engineer that he does not know in advance what he may or may not want the contract to cover.

E. S. DORR.*—If the contractors have nothing more to say, I think something might be said on the other side. Mr. Rollins has given us an excellent disquisition on what a contract should be, how it should be drawn for a fair-minded contractor. He has not told us what sort of contract we should draw when we have to deal with an unfair-minded contractor. It should be remembered that when the contract is being drawn the engineer does not know what kind of contractor is going to get the job. He has got to assume that he will not be a man who will meet him in this fair spirit, and therefore he must trust to the contract, and he draws one that will give him the advantage. That is to say, if a controversy is going to ensue, and the very practical question comes up as to who is going to have the whip hand in the contest, of course the engineer will try to secure it for himself. And I think in that consideration is to be found the answer to the question why these clauses are kept in. Of course, if the engineer be a fair-minded man, he is not obliged to do an injustice on account of having the ability to do it. But he is enabled by the presence of these clauses to do justice, because, having the whip hand, his hand cannot be forced by the contractor. I think that is the only justification for the presence of these clauses which our friends have been inveighing against. If all contractors were fair-minded and honorable men, I would agree with Mr. Rollins and the other speakers that these clauses would have been very much better left out.

E. S. LARNED.—On some work it has been found that inspectors who were intrusted with the passing upon the quality of materials and workmanship do not stop with that, but in their zeal and interest they go further. They attempt to direct the work. In other words, if the contractor is a man who is disposed to resist the dictation of that sort of an inspector, he may, under some conditions, claim that it is interference, and under the strict interpretation of the meaning of the act, the inspector is interfering. And in just so far as he does that he is doing the contractor a very great injustice. The contractor, on the other hand, realizes that it is policy for him to be reasonable, amiable and willing, and he oftentimes does things that he knows are causing him a very serious loss in the performance of the work. But he does it as a matter of policy. In my experience I have seen a very great change in just that feature of engineering work. I think there has been a distinct progress. Things are very much better now than in times past. Chief engineers have come to appreciate that they must look after their engineering assistants a little bit more closely, and that is a feature I would like to call attention to. Oftentimes contractors are not so much afraid of the interpretation of the engineer who draws the specification, or the man who is really in charge of the work, as they are of the assistant who is put in control of the work.

As to the engineer's not knowing in advance who is to take the contract. I don't like to designate a claim of that sort as being somewhat lame, but I think it could be very justly termed so. In the advertisement, and in the contract itself, the engineer distinctly reserves to himself the right to award the contract to the contractor who will best serve the interests of the other party. If a contractor is notoriously dishonest or untrustworthy, even though he be able to furnish bonds, there is no reason why the engineer should award him that contract. He would simply be inviting trouble. He should exclude that man's bid. Why does any reputable contractor make a reputation for himself? That is his capital, and if by so doing he can get contracts at a better price, he is entitled to them. There is no profit to an engineer or a corporation or an individual in having disreputable contractors do work. Trouble is bound to result, and nothing good can come out of it.

The fact that contractors take chances in specifications is a well-known fact. I don't believe one contractor out of ten reads the specifications in advance of his bidding carefully. He inquires who is the engineer. I don't think that is overdrawn a bit. In the last few years I have served in the capacity of adviser to contractors, engineers and architects, and have figured some work with them, and it has been particularly interesting to me to find the attitude of contractors toward engineers. When I inquired of them if they knew specially the features of the work they said, "No, we know the specifications call for concrete of certain proportions, rock excavation, earth excavation, piling, embankment, grading, etc.," but the particular requirements that mean cost are not so much referred to as is the question of who is to be the engineer. I think the significance of that is not to be overlooked, and if the engineer makes a reputation of being fair and practical in all matters of arbitration he will find in his following a class of contractors who will bid fair prices on his work and give him good quality and progress at all times.

F. P. STEARNS.*—Probably all engineers of experience have known of many instances where engineers, generally the younger members of the profession, have given arbitrary decisions which have added much to the cost of the contractor's work without materially improving the quality of the work under their charge, or they have modified plans in a manner to save some money for their client, regardless of the extra cost to the contractor of such modifications. As far as practicable there should be cooperation between the engineers who direct works and the contractors who execute them, to produce the required result at the smallest practicable cost.

In the writer's dealings with contractors in the past ten years there were very few who were not willing to do good work or who attempted to be dishonest in their dealings. When there has been trouble it has been, as a rule, with those who furnished supplies to the contractors. For instance, stone from one quarryman would come on the work cut substantially in accordance with the specifications, and in such cases an engineer should use many stones which do not come quite up to the requirements, provided the stone when in place would be reasonably satisfactory. On the other hand, another quarryman practically disregarded the specifications in cutting the stones and made them with much larger joints and not true to form. To have accepted such stones would have resulted in masonry of inferior quality to that specified and in paying a premium to the quarryman who did not do faithful work; moreover, only a part of the stone had been received, and if this had been accepted the remaining stones would probably have been even more carelessly cut.

There are several points which Mr. Rollins and others have made with regard to contracts with which the writer fully agrees. For instance, the contractor should not be held responsible for the stability of work designed by others provided the work is constructed as required by the specifications. There are, of course, exceptions to this rule, as it may be entirely proper to require an engine builder or a bridge company or other contractor with a large fund of technical knowledge to be responsible for the efficiency of a machine or other structure. The writer had supposed that a court would not find a contractor for public works responsible for the stability of a structure made according to the engineer's designs without some specific agreement to that effect, until he was connected with a case where a masonry dam failed in Alabama. In this case the dam failed, in his opinion, because its design was such that even if well built it would not resist the pressure of water at the height to which it rose in the river during a flood. The judge in this case ruled that the contractor would not have been responsible for the design of the dam had it not been that he had agreed in his contract "to complete the work and the whole thereof," and that it was not wholly completed. The dam was at the time completed in every part which affected its stability, so that the ruling of the judge was practically to the effect that the contractor guaranteed the design of the dam until its completion. Such a decision, while it may be legal, is not equitable, and engineers should endeavor to have eliminated from their contracts clauses which may result in such an inequitable decision.

There are many features of Mr. Rollins's paper with which the writer cannot agree after viewing them as nearly as he can in an unprejudiced way and from the standpoint of public policy. For instance, objection is made to clauses in contracts which in any way give the engineer control over the methods to be used to do the work. The writer has often found it advisable in tunnel contracts to provide for adequate timbering, safety appliances in connection with shafts and cages and ventilation. This control has been found necessary in the interests of the health and safety of the workmen, because many contractors are willing to take risks which ought not to be taken. As it is advisable not to have divided responsibility, the contractor is made responsible for the safety of the timbering, and the engineer's control is limited by the provision that he may require stronger timbering if, in his opinion, that proposed by the contractor has not sufficient strength.

It is also well that the engineer should have control of the time of removing centers from arches, as there is often a tendency on the part of a contractor who requires the centers for use in another place to remove them too soon, with material detriment to the quality of the work, and, although the contractor is supposed to be responsible for the work, it is not feasible in practice to condemn completed work unless it is positively bad.

As a rule, the writer believes that the contractor should be left free to plan temporary works, but there should be exceptions to this rule when the works are so extensive that they require technical skill for their design and where the failure of the temporary works would lead to great delay and loss. As instances of temporary works which I think it advisable to design and pay for, I would include large flumes for carrying the floods in a river past a dam during its construction, and important cofferdams. To leave these wholly to the judgment of the contractor and permit him to bid a lump sum on a work that is not designed seems entirely contrary to the interests of the intelligent and cautious contractor, as some more ignorant or venturesome contractor is liable to underbid him in such work.

The question then arises as to who should be responsible for such designs. If they were not liable to be weakened by the manner in which the contractor conducts his work, there is no question that the responsibility should rest with the party making the designs, but a cofferdam depending upon an earth bank for its stability may fail when the enclosure is pumped out if the water is lowered too rapidly, or, in the processes of excavation, the inner toe may be undermined and weakened and require bracing. It, therefore, seems clearly desirable, in order to avoid divided responsibility, to place the whole of the responsibility upon the contractor and to provide that he may strengthen the cofferdam as much as he wishes or may adopt other designs of equal or greater strength approved by the engineer.

In the case of a flume, which was built before the contract for a dam was made, to carry the water of a river past the site of the dam, the contractor was permitted to strengthen the flume if he thought it advisable, and was made responsible for maintaining the flume, because he would necessarily undermine it to some extent by his operations. On the other hand, he could not enlarge the flume, and the other party to the contract was made responsible for the damage, if any, due to inadequacy of size.

Practical experience shows that it is not wise, especially where work must be done within a given time, to permit a contractor to take great risks, like that of the breaking of a cofferdam, because it inevitably results in delay and almost as inevitably in a suit on the part of the contractor.

Especial objection is made in the paper to the clause in a contract "which makes the chief engineer the sole judge of everything," and arbitration by two persons, with a third one to be chosen in case they cannot agree, is suggested as an alternative. It must appeal to engineers and others that it is difficult, if not impossible, for an engineer who prepares plans, writes specifications and is interested in the construction of work at a low cost, to be entirely unbiased in his judgment. He is likely to lean either in the direction of his employer, or, recognizing his somewhat anomalous position, to lean toward the side of the contractor. The suggestion of arbitration is always attractive, as one can picture two entirely disinterested intelligent persons of judicial temperament, who will listen to what is told them by the contractor and the engineer, and then proceed to investigate for themselves and reach an entirely fair conclusion; but experience shows that this is an ideal and not a practical condition in most cases.

The cases with which the writer is most familiar are those in which it has been attempted to ascertain the value of a water-works property which has been taken by a municipality or a state, by a method which is very similar to the arbitration which is proposed as a substitute for the judgment of the engineer. In these cases a commission is chosen, nominally by the court, but practically two members are chosen, one each by the two parties. Instead of selecting parties of a judicial temperament, who will be likely to reach about the same conclusion, one side selects a man noted for large awards and the other a man noted for small awards, and after considerable difficulty a third member is usually chosen who is more or less of an unknown quantity. Eminent counsel are engaged on both sides, with assistant coun-

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sel, and the country is scoured for experts, among whom will be found on one side those who are noted for the testimony they have given of great valuations of property and the others for lower valuations. The case then is likely to go on for a long time before it is finally concluded. There is one result which is certain to occur, namely, that a considerable percentage of the award is paid to lawyers and experts and for the expense of conducting the case, and yet I believe the results are not, as a rule, nearly as fair to both parties as the judgment of the engineer. In such arbitration there is nothing "of the old principle of man-to-man settlement."

A large share of the contracts are drawn by the commonwealth, the cities and the railway corporations, and in a law suit they are generally at a decided disadvantage as against the individual or the small corporation represented by one or more very active individuals; and those who draw the contracts will, and in the writer's judgment should, continue to draw them on the basis of avoiding litigation. He also believes this policy to be in the interests of the fair-minded contractor, who would not gain enough through arbitration or legal procedure to offset the extra time and expense involved.

Strong objection is made in the paper to the use of the words "except as otherwise directed." This provision, together with the usual provision that "the engineer may make alterations in the line, grade, plan, form, dimensions or materials of the work," may seem very arbitrary, but the writer has always assumed that it would not be feasible or even legal for the engineer to make radical changes under the authority given by these provisions; and minor changes must be provided for.

It is suggested in the paper that "the contract must be explicit in all its terms"; also that "the engineer should know what he wants when he writes his specification." The writer has yet to know the engineer who, in connection with important work, is able to tell at the time he writes his specifications just what he wants in all details. He may know what he would like if the conditions prove to be as he expects, and yet is likely to learn during the progress of the work, especially where much of it is underground or under water, that the conditions are not what he expected and that there must be some modifications of the views which he held when he wrote the specifications. He should, in writing the specifications, state in them as explicitly as possible what is to be done, but for the benefit of his client and of the contractor there should be such provisions as those above mentioned permitting the engineer to modify the work in view of the further information obtained during its progress. The contractor does not always recognize that the engineer is not a party to the contract and that he has no right to make any changes except as he is specifically given that right by both parties to the contract.

The writer believes that it would be unfortunate for the contractor as well as for the other party to the contract if the engineer were not authorized to use his discretion as to changes in plan. Mr. Rollins seems to have given an instance when he says, "Plans showed 6-in. hard pine sheeting driven to a depth of minus 20, and specifications said simply sheet piling shall be driven as shown on plans." In this case, apparently, the engineer was not authorized to make any changes and the owner held the contractor to the requirements of the contract.

In the writer's own experience the authority to make changes has benefited the contractor more frequently than it has injured him, because the modifications of plans have generally been such as to facilitate construction. If a contractor were required to conform to the terms of an explicit contract I think he would soon be glad to return to a form of contract in which the engineer could use some discretion.

J. L. HOWARD.*—The author claims upon the ground of mutuality in a contract that it is the duty of the engineer to guarantee the correctness and reliability of all borings taken under his direction prior to the letting of the contract. It seems to the writer that contractors have no basis for making this claim if the borings are made by a firm accustomed to that kind of work, and if the different samples are properly located and labeled, and the contractor is at liberty to examine them for himself any time before his bid is submitted. When this is done, hasn't all been done that any reasonable contractor has a right to expect? In such case the contractor has all the data that the engineer possesses, and in case it develops during the prosecution of the work that the materials passed through are different from those indicated by the borings, isn't that one of the legitimate risks which a contractor expects to assume in undertaking work below the surface of the ground?

Several of the phrases to which the author takes exception in specifications are very similar to the specifications for work under the writer's direction. In the clause "timber attached to the masonry," where the contractor is required to embed in or attach to the masonry sills and bearing timbers and such other timbers as may be required, the author apparently objects to classifying frames for tide-gates under the head of "timber," but a little farther on in the specifications it is specifically mentioned that bearing timbers for the tide-gates and sluice-gates were included in this item, and the writer fails to see where wooden frames bolted together are any the less timber for that reason.

Regarding masonry joints, the author quotes three instances where it appears that a wide joint has given better results than a thin one, and further on says, "We can't ask you to discharge your inspectors and take everything that comes, but we can and do ask for reasonable inspection; * * * but when work goes out of sight, or under ground, or under the sea, a pea-green stone is as good as cadet gray, and a ⅞-in. joint as good as ⅝-in." The words "reasonable inspection" are liable to be interpreted quite differently by different people. To the engineer they might mean compliance with the specifications as written, and if the engineer called for ½-in. joints over all the work, whether under ground, under the sea, or in plain sight, why shouldn't he have them? On the other hand, to the contractor they might mean that the specifications should be carried out to the letter only when the work in question is in some exposed place where the general public would view it plainly each day, but that where the work was out of sight, something not quite so good, perhaps only in appearance, although just as solid, ought to be allowed. Now every engineer on any large work always allows some divergence from the specifications in small matters not affecting the stability or permanence of the work, but they seldom get any credit for doing so from the contractor, and if the engineer tries to enforce the letter of the specifications in particular cases where it seems to be essential, he is often met with the cry of exacting "the pound of flesh." It seems to the writer that allowing variations from the specifications is a dangerous custom, causing constant friction between the engineer and contractor, because if it is done once, why can't it be done again and again, and of course it is not fair to the other bidders who perhaps put their prices high enough to cover the cost of the work as called for in the specifications and possibly by that means brought their total so high that they failed to get the contract.

It seems to the writer that this whole question is largely due to the practice of contractors bidding for work under certain specifications with the expectation that if the contract is awarded to them, they will be allowed to do the work in their own customary manner. A large number of them seem to act as if the various clauses, which say that the engineer shall be the authority to decide as to the meaning and intent of the specifications, as to the manner in which the work is to be done, and that the work is to be done to his satisfaction, should read that the contractor is to be the one who will decide as to the meaning of the specifications, and to decide as to the way and manner in which the work is to be done, etc. And it seems to the writer that all of these troubles will be largely obviated if the contractors, upon signing a contract, will make up their minds to comply with the specifications as printed and not attempt to substitute others of their own.

A. D. FLINN.*—Mr. James W. Rollins, Jr.'s, paper is particularly timely and suggestive to the engineers of the Board of Water Suply of the city of New York, who are just preparing the first large contracts for one of the greatest engineering projects of the times. With many of the criticisms of recent contract practice the writer heartily concurs, but it seems that the author tacitly, at least assumes a righteous and capable contractor. Such a one, we regret to say, is not always the "party of the second part." The engineers and the legal counsel for a municipality or a corporation must guard against the irresponsible and unprincipled as well as the incompetent bidder, especially in public lettings in which the lowest bidder must receive the award. Hence, contracts and specifications must be drawn, in the majority of such cases, to provide for dealing with the worst man or organization rather than the best by whom the work may be done.

The difficulty just mentioned has been obviated to some degree by giving to public officials, and by reserving in the advertisements for proposals, the right to award the contract to the bidder whose bid, all things considered, is for the best interests of the municipality or corporation. This puts considerable responsibility upon the chief engineer, as it usually falls upon him to investigate the bidders and report, with recommendations, to his principals. If this power be abused, there is danger of discouraging competitive bidding, and, therefore, unless there is very good reason, contracts should not be awarded to other than the lowest bidder. Opportunity, however, is provided for avoiding the exceedingly undesirable contractor who, under the rigid method of awarding to the lowest bidder, becomes a great trial to the engineer by performing the work unsatisfactorily and possibly at considerable loss to both parties.

It may be noted that in some places "extra work" clauses are not permitted in public contracts. In such cases apparently the only method for doing additional or extra work is by subsidiary agreement. In some instances, if the cost of such work exceeds a certain relatively small amount, bids must be obtained.

Engineering is exact only in part, even theore[tically]. Conditions of construction of civil engineering w[orks] involve many uncertainties, especially in long-tim[e] contracts for works of great magnitude. Therefore c[on]tracts and specifications for such works must be suf[fi]ciently flexible to meet changing conditions with fairness [to] both parties. Many questions and emergencies will ar[ise] demanding decision by some one in authority with i[n]timate knowledge of the work, and as yet there seems to [be] no one better qualified than the engineer.

Mr. Rollins objects to the clause frequently found in specifications that inspection shall not relieve the contractor, etc., and that faulty work which has passed inspection may still be rejected. In this connection it is well to bear in mind that inspectors are sometimes bribed or otherwise influenced by unscrupulous contractors, and there is, therefore, need for the provision just quoted. Furthermore, some forms of deception which are practiced in construction, perhaps without any knowledge and even contrary to the orders of the contractor himself, are not readily detected at first, and hence pass first inspection, but become apparent later. It seems to the writer that this clause does not interfere with the mutuality of the contract, as both parties are assumed to be working to accomplish good results.

Exactness of specifications is desirable so far as feasible, and there is room for much improvement in this line, but the writer believes that steady progress is being made by engineers in this direction. Lack of exactness is caused, as the author suggests, frequently by lack of definite knowledge on the part of the engineer. This is due not infrequently to the fact that an engineer has to cover a wide range of work in the specifications for a large project, and some of the details are relatively so minor that he cannot afford to get exact information in advance. Possibly too much is passed superficially in this way. Lack of suitable standards of excellence seems to be another reason for lack of definiteness in specifications. At times this lack is very hard to supply, especially if the character of the work is different from any which has been performed in the same locality previously.

It seems to the writer that little is to be gained by making other than the engineer the referee under a contract for engineering work. Occasional unjust engineers there may be, but the unjust are to be found among judges also, and among referees of all kinds. An outsider cannot have the intimate knowledge necessary to a fair decision, and time must be lost in informing any such referee or committee of referees chosen to arbitrate. It does not seem boastful to say that, as a class, engineers are fair-minded men.

Experience and observation lead the writer to believe that the engineer should rarely dictate the methods or plant to be used by a contractor. Occasionally this may be very desirable. When an engineer does thus dictate, it would seem only fair for the contractor to be relieved of the share of responsibility which does not rightly belong to him.

J. P. SNOW.*—The two essential elements of an agreement between an owner and a contractor for executing work are the plans and specifications. To these may or may not be added a contract.

The plans should show the dimensions, location and details of the work as far as graphics can properly do so. Notes enough to describe particular features should be added, but, speaking broadly, the plans should contain but few written directions.

The specifications should show the conditions surrounding the execution of the work, the classification under which it is to be paid for, detailed descriptions of its several items, the quality of its materials and the class of its workmanship. It is the book of reference for the contractor's foreman and the inspector or owner's agent. If it is clear and complete, misunderstandings will rarely arise. "Or as directed by the engineer" is a phrase that seems unavoidable in some instances in specifications. But it should be used as sparingly as possible, for it is a confession of inability on the part of the engineer to define what he wants done, and is a manifest invitation to the bidder to gamble on uncertainties.

A contract may well be simple. A signed statement that "I, John Smith, for certain considerations, agree to do certain work for John Doe, according to certain plans and specifications, and to his entire satisfaction" covers the whole ground, and no amount of phrasing will make it stronger.

These three elements of the agreement, viz., plans, specifications and contract, should be cooperative, but neither should repeat what the other contains. Each has its essential field and should be restricted to it. The whole reason to be of these documents and the feature of supreme importance in them is a clear and precise exposition of the understanding between the interested parties of the exact nature and extent of the work to be done.

Our author has made a plea for fair play on the part of engineers and inspectors. He should not expect this unless he is willing to reciprocate. The contractor who pretends to be in doubt as to whether a uniform color was intended of all the stones in a piece of masonry or simply for each stone so that a speckled hen effect would

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obtain, when the specification read, "The stone used in the work * * * shall be uniform in color," deserves to have to furnish mosquito frames by board measure and have the mitered corners deducted at that. Speckled masonry may be as strong as any other, but sometimes other features than strength are essential.

Engineers, when writing specifications, will welcome hints from contractors, with a view to clearness and smooth working, and I for one am obliged to the author for bringing out the points set forth in his paper. When civilization shall have advanced so that competitive bidding is history, a part of our present difficulties will have disappeared.

L. C. WASON.*—In the writer's opinion it is very frequently the fault of the owner that unfair articles are inserted in contracts. In some cases he does not pay a full commission and the engineer, therefore, will not go to the expense of finding out and assuming responsibility for the accuracy of borings or other uncertainties encountered. A few engineers throw responsibility for all uncertainties to be encountered upon the contractor to save themselves the trouble of the careful study necessary to determine the exact conditions. Sometimes an owner does not allow an engineer sufficient time to do his work thoroughly, and therefore he is compelled to resort to phraseology of contracts which relieves him of all of his own responsibility and requires the contractor to assume it.

Engineers in the permanent employ of an owner are liable to become biased—it may be unconsciously, but nevertheless certainly—from long continuation in one line of service, and they look and act from the viewpoint of the owner rather than from that of a disinterested referee between the owner and the contractor. Public works departments of cities, states and the United States and the railroads employ a permanent staff, and it is the writer's experience that the contracts and specifications from these sources are subject to criticism most generally, and that there is little criticism to be found with the work emanating from private sources.

The writer has largely withdrawn from public work on account of unfairness encountered not only in contracts and specifications, but in the system of administrating them, and because this system has brought into this line of work a class of contractors who are plungers and who gamble on conditions, cut prices, and skin the work when they can. Under such conditions it is hard to get a fair price for the work. One-sided, unfair contracts foster this class of contractors, while fair and mutual ones will bring forth a better, honorable and honest class in large numbers.

It would be a distinct advance if owners as a class could be made to realize that there is positively nothing which raises a bid like asking a contractor to assume uncertainties which may be encountered, and that the engineer earns his money by eliminating such uncertainties, thereby reducing the cost probably more than his own commission amounts to and perhaps several times over; and secondly, that by eliminating all unfair and unreasonable clauses a much better class of bidders can be obtained; thus good workmanship can be secured and usually at a lower price than can be obtained from the cheaper class of workmen who gamble on the uncertainties. Let the owner assume all uncertainties. If difficulties arise, he pays the price he would pay anyway, and if they do not arise he wins this amount instead of the contractor. This method implies percentage or lump-sum profit work on the uncertain items, but he has the safeguard of having to pay only once for having his work done right. If the work is not done right the first time, or if carelessly or negligently handled, the owner is no more subject to pay the price of making the work right than if it was done on the ordinary lump-sum contract basis.

Mr. Rollins, in closing his paper, alludes to the courts being left for the Boston Elevated cases. In this connection the writer would like to call attention to one clause from a Boston Elevated contract for desirable work on which he declined to estimate because, in his opinion, it was an invitation to trouble. It is well known that the Boston Elevated and other large corporations are held up for blackmail and are used for causes just and unjust. This clause, which is as follows, endeavors to shoulder on to the contractor trouble which may be real or only alleged to be real:

> In case any claim is made against the railway company, which claim is based upon, grows out of, or is alleged to grow out of, anything done in reference to matters contained in or incident to this contract, the railway company may retain such sums as in the judgment of its president will indemnify it against any loss; [and further] in addition to damages indicated above, may deduct reasonable charges incident to the investigation and defense of such claims.

This same contract also requires the contractor to guarantee the sufficiency of the engineer's plans and specifications in all particulars. It is hoped that all contractors will protest against contracts of this nature. Those who will not are deserving of all the trouble that can come to them.

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J. W. ROLLINS, JR. [author's closure].—Some contend that to protect themselves engineers must make a contract and specification for a dishonest one. Almost every contract for public work provides "that the work shall be let only to bidders who can furnish satisfactory evidence that they have the ability and experience to do the class of work called for, and that they have sufficient capital and plant to enable them to do the work successfully and to complete it within the time named in the contract." Why isn't this clause protection enough for any engineer, and sufficient ground for him to reject the bid of any dishonest or incapable contractor and let a good one have the work?

We contractors also know perfectly well that the personality of the engineer can make or break us, and the writer leaves out in this statement any question of actual honesty or dishonesty; that is, in plain words, *if an engineer demands in full every and all conditions of the specification to be carried out the job is a failure financially.* Opinions are expressed in the discussions that such a contractor should fail, that he has agreed to do certain work and that he should be made to do it, made to do perfect work. Are engineers perfect? Can perfection be obtained in many things—in any thing? Perfection is exact compliance with specifications; but may I ask, Is the work better or stronger because a joint is exactly ½-in. or the color is the exact shade called for," especially as most masonry is discolored in six months after being laid? But as long as we have engineers we shall have the exact ones, who will have their pearl gray color and their ½-in. joints, their measurements to a thousandth, with perhaps their feet wrong. The writer knows of such engineers—perfectly honest but not just and fair—men for whom contractors will not work at any price, and whose reputation even among their fellow-engineers and their superiors is that of a "grandma."

Certain engineers seem called upon to assume all responsibility of design of temporary work, and then disclaim responsibility in results. Hasn't the time about come for such men to realize that among the contractors are engineers who know their own business, and who knowing it will be thoroughly able to protect their own interests; or who, if they are not themselves technical men, are good enough business men to get an engineer to figure out for them anything necessary?

Mention is made that never does an engineer know what he wants when the contract is let. How then does he expect the contractor to make an intelligent bid?—for if the engineer doesn't know, the contractor surely doesn't. It is admitted that plans cannot be perfected in a short time, but surely an engineer should know what kind of cement he wants as to chemical analysis; what kind of sand he wants as to size; what size piles he wants, and all such matter, when he writes the specifications. As to plans being perfected before contract is signed, the writer recalls two large contracts executed by his company, almost adjoining, and built under almost exactly the same conditions. On one contract plans were made in detail and a lump sum price submitted, and so well did the engineers do their work that on a contract of $600,000 there was never a charge for extra work on account of any error of plan, nor any row with engineers over meaning of plans or specifications. On the other job, work was let by items, on a general plan. When the detail plans came out, in many places most expensive forms were needed; concrete shown in massive walls was changed and built full of economy holes; then walls were built with steel reinforcement, that is, steel concrete was substituted for ordinary concrete, at the latter's price. We all expect changes, and that such are necessary; but we do not expect, and we do object to, changes such as mentioned, made to save money for owners, and cost us money to execute. When such changes come, discussions, disputes and bad feelings arise, and unless the engineer is fair enough to admit the value of such changes and pay for them a loss falls to the contractor. This experience has led the writer to always favor a lump sum contract.

The writer proposed to bar six stipulations; and, to emphasize the matter, will repeat them:

(1) Disclaiming responsibility for soundings or other information as to the character of the work.

(2) The insertion of clauses which make any contractor's estimates worthless by adding, "or as otherwise directed."

(3) Making the contractor responsible for work for which engineers make the plans or require their approval to any made by contractor, and where engineers reserve the right to entirely control the manner and means of construction.

(4) Holding contractor responsible for work which has passed inspection or has been done under direction of engineer, or his agent, or inspector, unless fraud can be proved.

(5) Making the engineer the sole referee in settling all claims.

(6) The right to stop work, or any part of it, if for the interests of the company so to do, without allowing the contractor anything for the loss such action might bring to him.

With these eliminated from contracts, with specifications explicit in defining qualities of material wanted; and with a fair interpretation of such specifications, having in mind the source of supply and the work in hand, then, in the opinion of the writer, we shall have the "square deal" we ask for.

MUNICIPAL CEMENT PLANT FOR THE LOS ANGELES AQUEDUCT.

A municipal cement plant of the capacity of 1,000 bbls. per day is proposed for making the cement required for the construction of the Los Angeles Aqueduct and accompanying works. Bids for this plant are to be opened on Oct. 7, as advertised in our issue of Sept. 19. Very comprehensive specifications for the plant, with complete lists of all the machinery and appurtenances required, are given in the specifications adopted by the Board of Public Works of Los Angeles, Cal., on Sept. 3. Mr. Horace B. Ferris is Secretary of the Board of Public Works of Los Angeles, and Mr. William Mulholland is Chief Engineer of the Los Angeles Aqueduct. The specifications call for three rotary kilns, crushers, pulverizers, dryers, conveyors, elevators, cars, pulleys and shafting, all of which are described in great detail in the specifications. Some of the general clauses of the specifications, together with statements regarding the number and character of the principal components of the plant, are given below.

The plant will be located at Tehachapi, Cal., and so far as we know, will be the first cement plant ever built by a city, and the second one built at public expense. The other publicly-owned plant is supplying cement for the great Roosevelt Dam, some miles from Phoenix, Ariz., and was built by the U. S. Reclamation Service.

The extracts from the specifications follow:

CONTRACTOR'S SPECIFICATIONS.—Each bidder must attach to his proposal and make part thereof specifications, to be designated "Contractor's Specifications," which shall contain detail descriptions and drawings or cuts of the parts of machinery and apparatus, and kind of materials to be furnished or used in the construction of machinery and apparatus which the bidder proposes to furnish. In case the Contractor's Specifications conflict in any particular with the detail specifications of the City, the latter shall govern in determining the point at issue.

OPERATING GUARANTEE.—The Contractor shall guarantee for 60 days after beginning operation the material and workmanship furnished by him to be free from defects of design or construction. He shall replace free of all expense to the City any defective material or any apparatus which shall develop faults during said 60 days after the same is placed in operation.

ROCK CRUSHER.—One gyratory crusher equivalent to the No. 6 Gates pattern, with suitable driven and driving pulleys.

CLAY DISINTEGRATOR.—One 24-in. clay disintegrator, complete, of capacity sufficient to break up 100 tons of damp, lumpy clay in 10 hours, and of such pattern that it will not clog up if the clay should carry 18 to 20% moisture, in weight.

DRYERS.—Two standard pattern rotary dryers, each 5 ft. in diameter by 50 ft. in length; either cylindrical or tapered shells.

ROCK EMERY MILL FOR CLAY GRINDING.—One 42-in. vertical runner rock emery mill of 10 tons dry clay hourly capacity.

FOR ROCK GRINDING.—Capacity: 300 tons of limestone are to be ground every 20 hours so that all will pass a 20-mesh screen and 50% will pass a 100-mesh screen.

Three No. 8 Ball Mills—Approximate dimensions 9 ft. diameter × 4½ ft. long. Heads on side walls to be of rolled steel.

MIXING MACHINE.—A mixing device capable of accurately proportioning dry ground limestone and clay in the proportions of 300 lbs. of limestone to 95, 96, 97, etc., lbs. of clay as may be desired. The capacity must be 21 tons of limestone to 7 tons of clay per hour.

FOUR TUBE MILLS.—The shells of mills are to be 6 ft. diameter by 16 ft. long and of substantial construction with dish-shaped heads and designed so that the connection of gear to the head is independent of the connection of head to shell.

KILN-FEEDING DEVICE.—Three automatic kiln feeders for delivering raw mixed materials to the rotary kilns.

THREE ROTARY KILNS.—Shell of [each] kiln to be 100 ft. long, made of $^{9}/_{16}$-in. steel plate; 87 ft. from the lower or discharge end of shell will be 7 ft. 6 ins. outside diameter, and the remaining 13 ft. will taper from 7 ft. 6 ins. to 5 ft. diameter on end.

CEMENT-GRINDING MACHINERY.—Capacity, a min-

imum of 200 tons of clinker to be ground every 20 hours, to a fineness of 75% passing a 200-mesh screen.

Three No. 8 ball mills.

Four tube mills.

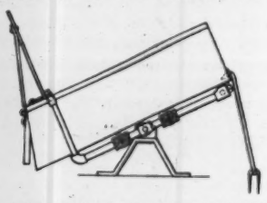
Ball mills to be furnished with initial charges of suitable balls.

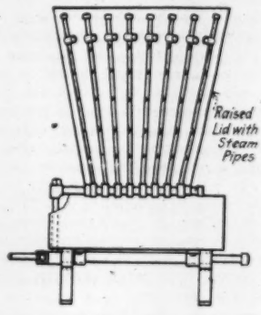
AIR SEPARATORS.—Four air cement separators complete. Capacity: Each separator to take cement of a fineness of 60% passing a 200-mesh screen, and deliver a product of 75% passing a 200-mesh screen, at a minimum rate of 15 bbls. an hour of finished cement.

A MACHINE FOR HEATING CONCRETE AGGREGATE.

The accompanying figure illustrates a machine patented by Mr. R. C. Huffman, of Baltimore, in which stone and sand may be heated preparatory to laying concrete in freezing weather. The heater consists of an oblong box, 6 ft. long, 5 ft. wide at the rear, 2 ft. wide at the front and 18 ins. deep, provided with a hinged cover and mounted on bearings on a base or stand 18 ins. high. Slotted pipes, from which live steam issues, extend along the top, sides and bottom.

In the construction of two tunnels on the Washington, Baltimore & Annapolis Ry. last winter this box heater was used to great advantage. During January and February some 3,000 cu. yds. of concrete were laid in freezing weather, and although no covering was placed over the work at night the low temperature has had no effect whatsoever on the concrete. In this instance steam was supplied from an additional 10-HP. boiler, run by the same engineer who had charge of the mixer engine.





STEAM HEATER FOR CONCRETE AGGREGATE IN FREEZING WEATHER.

The sand and stone are measured before placing in the heater, just enough being used each time to fill a batch mixer. In this way a batch may be heating at the same time one is being mixed.

THE SOUTHERN PACIFIC RY.'S NEW ENTRANCE TO SAN FRANCISCO, CAL.

The Southern Pacific Ry. has now under construction a new line which will greatly improve its entrance to San Francisco, and which involves some very heavy construction work. The general situation is shown by the accompanying map. The company's principal lines from the north and east terminate at Oakland, on the east side of San Francisco Bay, and passengers are carried to and from San Francisco by ferries. The only available rail connection passes entirely around this inland bay (by way of San Jose), and is nearly 100 miles in length. From the south there is a direct line into the city, but it has an unfavorable location and poor terminal facilities. The new lines will provide a direct route into the city for both the eastern and southern main lines.

The first portion of the cut-off commences at Niles, where a line from Stockton (forming a connection with the main line from Ogden and the east, and also with the main line from Los Angeles and the south) strikes northwest to Oakland. This new line (marked A on the map) extends westward to the bay, which it crosses at the Dumbarton narrows. This portion is comparatively easy of construction, lying across farm land and tide flats. It consists largely of embankments, with nearly 1½ miles of ballasted-floor trestle approaching the deep water channel at Dumbarton. This channel will be crossed by a double-track steel swing drawbridge 300 ft. long, giving two clear openings of 125 ft. in width. A similar bridge, but of less length, will cross another channel west of Newark. This line will be 16 miles in length, connecting with the main line into San Francisco (from the south) at Redwood.

The second and most important portion of the work, leaves the main line just mentioned at San Bruno and follows closely along the shore of the bay into San Francisco. This is the Bay Shore cut-off, shown at B on the map. This line will be ten miles in length, effecting a saving of four miles in distance, but also avoiding some severe grades and a number of grade crossings in the city. The maximum grades are 0.3%, compensated for curvature. There are only ten curves, and these are from 0° 30′ to 2° 54′, except for a 4° curve at the San Bruno connection. The right-of-way and the general design are for a four-track railway, bringing all the principal traffic directly into San Francisco, but at present only two tracks are being built. The other tracks will be built when the increase of traffic makes them necessary. It is stated that an electric interurban line may acquire the abandoned line between San Francisco and San Bruno.

As an irregular line of steep hills forms the west shore of the bay, very heavy cuts and a number of tunnels have been required to carry the road through the projecting spurs. Heavy embankments cross the ravines and several indentations of the bay. The largest embankment is 6,000 ft. long, with a top width of 70 ft. and a height of from 10 to 50 ft. The heaviest cut is at Visitacion Point, where 800,000 cu. yds. were excavated in earth and rock. It is 1,250 ft. long, with a maximum depth of 150 ft., the top width at this point being 300 ft., while the width at subgrade is 60 ft., including the ditches. There are five tunnels concentrated on a stretch of five miles, and aggregating nearly two miles in length. The first two tunnels (from the north) are 1,817.3 ft. and 1,088.4 ft. in length, and are driven through massive serpentine rock with clay seams. No. 3 (2,364 ft.) is partly through wet sand with seams of clay and partly through a very hard silicated formation. No. 4 (3,547 ft.) is mainly through very wet ground with quicksand and clay layers, and partly through shale of medium quality. No. 5 (1,133.8 ft.) is in hard sandstone.

Map of New Lines Forming the New Route Into San Francisco; Southern Pacific Ry.

The tunnels are 30 ft. wide (with tracks 13 ft. c. to c.), and have vertical side walls to the springing line, 10 ft. above the floor or 8 ft. above rail level. The arch is of 15 ft. radius, [illegible] four to six rings of brick, according to [illegible] material passed through. The side walls [illegible] are of concrete, the invert having a fall [illegible] to the center. The packing behind the [illegible] and arch is in some places of concrete [illegible] where it is of broken rock. Power d[illegible] only used in the one tunnel which passed [illegible] hard sandstone. In all the other tun[illegible] side headings or drifts (8 × 7 ft. clear) [illegible] driven at the bottom, followed by two [illegible] headings immediately above them and of [illegible] same dimensions. These were separated [illegible] a timber floor. A top center heading [illegible] driven along the crown. This arrange[illegible] a center core about 13 ft. wide and 18 [illegible] supporting the timbering. This was [illegible] excavated, the removal of the material [illegible] the top side headings and the top center [illegible] being the final operation. All excavated [illegible] was hauled out on cars from the bottom [illegible] headings, being delivered to them by chutes. The arch centering consisted of 10-in. I-beams, each rib being in two sections, with a bolted connection at the crown. In the completed portion of each tunnel was a timber traveler, with platforms connecting with the tracks of the center and side headings. This was fitted with an electric hoist for handling timber, brick, concrete, etc., to be run into the headings on the tunnel cars. The average progress at each end of each tunnel was a little over 4 ft. per day.

Five miles from the city, and north of the big cut at Visitacion Point, is an area of some 200 acres reclaimed by filling with excavated material from the cut and with sand pumped by electrically-driven suction dredges. Here there will be extensive freight yards, division repair shops, locomotive terminal facilities, etc., so as to relieve the city terminals. Gravity switching will be employed in the yards, with two humps serving the northbound and southbound classification tracks respectively.

Part of the construction work has been done by contract, and the remainder by company forces. On the Bay Shore line, two of the tunnels and most of the grading were done by contract. Tunnels Nos. 1, 3 and 4 were built by the company's forces under the immediate direction of Mr. W. E. Marsh, Assistant Engineer, who was in charge of the entire work. All the work was under the direction of Mr. William Hood, M. Am. Soc. C. E., Chief Engineer of the Southern Pacific Ry.

SAN FRANCISCO SUBURBAN LINES of the Southern Pacific R. R., radiating from Alameda Mole, Oakland, are to be electrically operated.

This is a rapid transit service, about the eastern side of San Francisco Bay, connecting at the Oakland pier with a line of ferryboats to San Francisco. The lines are, roughly, seven miles long with stations a little less than half a mile apart on an average. The proposed electric service will employ multiple-unit trains of 3 to 12 cars each, part of which will be motor cars and part trailers. Direct current will be supplied from an overhead catenary line construction. Contracts have been let to the General Electric and Westinghouse companies aggregating about $000,000. These contracts call for 80 motor cars each equipped with four General Electric 125-HP. motors and power-house equipment for two 5,000-HP., 25-cycle, 13,200-volt, three-phase Westinghouse generating units. The Southern Pacific's competitor for the suburban traffic in this district is the San Francisco, Oakland & San Jose Ry., popularly known as the "Key Route." This service comprises a line of fast ferries to an Oakland pier and electric trains about Oakland and to Berkeley.

THE CONSTRUCTION PLANT on the Isthmian Canal work is summarized as follows in the "Canal Record" of Sept. 11:

Equipment.	June 30, 1906.	June 30, 1907.
Steam shovels, 45-ton	1	3
Steam shovels, 70-ton	15	28
Steam shovels, 95-ton	23	32
Locomotives, French	100	100
Locomotives, New American	20	184
Cars, French dump	541	250
Cars, American	324	455
Cars, American flat (wood)	1,001	1,501
Cars, American flat (steel)	500	500
Lidgerwood unloaders	12	18
Bank spreaders	13	13
Unloading plows	22	33
Track shifters	0	3
Pile drivers	1	7

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To the ordinary citizen, unfamiliar with the intricacies of "high finance," it seems passing strange that the street railway system of the city of New York, carrying a traffic more dense than is to be found anywhere in the world, should be placed in the hands of receivers, because of inability to pay its debts.

We have no intention of setting forth in this place all the reasons why the management of this property was turned over to appointees of the U. S. Court. The fact that it is commonly referred to as a "friendly" receivership may serve as an indication of certain reasons for the present action which are kept hid from the public and from the owners of the company's "securities."

Neither shall we attempt any explanation of the maze of leases, and re-leases, of "holding companies" and "withholding" companies, in which the whole street railway system of New York City is involved. If the purpose of those who have woven this complicated web of corporation entanglement was to so mystify the holder of stocks or bonds that he would dispose of his property at a sacrifice to those on the inside, rather than attempt to fathom the mystery as to what his paper certificates really represented, —if this was the purpose, it has no doubt been fully accomplished.

We shall make no attempt to explain the tangle involved in the ownership by the $200,000,000 Interborough-Metropolitan Co. of 95% of the shares of the Metropolitan Securities Co., which owns the stock of the Interurban Street Ry. Co., which has changed its name to the New York City Ry. Co., and which is the lessee of the Metropolitan Street Ry. Co. and of some twenty other street railway corporations, the said Metropolitan Street Ry. Co. being itself the lessee of a number of other corporations and controlling others through ownership of stock, and so on and so on.

We purpose simply to point out here that the street railways of New York City, or rather the surface lines operated by the New York City Ry. Co., earned $21,938,000 gross in the year ending June 30, 1906, and after paying all expenses of operation had a net income of $9,738,000. The reason for bankruptcy notwithstanding this princely income is that the fixed charges on the system last year amounted to $11,951,000. According to "Poor's Manual" for 1907, this street railway system is staggering under a load of bonded debt amounting to $120,083,000. Its total mileage of tracks, including everything it has laid, even the tracks in the car barns and many miles of unused track kept in service only to obstruct traffic and hold down an ill-gotten franchise, was 516 miles. Of this total 92 miles is horse railway tracks and 201 miles is overhead trolley lines in the Borough of the Bronx and in Westchester County. The actual construction cost, therefore, of some 300 miles of the whole is a very moderate sum, and even the most extravagant estimate of the cost of the electric conduit lines on Manhattan Island fails to account for this enormous funded debt of over 120 million dollars in any legitimate way.

We may add, incidentally, that besides this bonded debt, the "Manual" shows that this remarkable child of high finance had on June 30, 1906, "current liabilities" of $66,000,000. Probably by the time the "friendly" receivership is terminated, a goodly portion of these "current liabilities" will be converted into permanent charges upon the system's earnings.

The plain truth is that the whole street railway situation in New York City, and its entire history since the days of Jacob Sharp and the boodle Board of Aldermen is a record of wholesale corruption, theft, swindling and outlawry which by comparison makes burglary and highway robbery seem modest and innocent occupations.

The public treasury has been looted of valuable franchises and of its due quota of taxes at the same time that honest investors have had their pockets picked; and the whole dirty business has been carried on with the aid of men of supposedly high standing in the financial and professional community. It is not without interest in this connection to note how much of the published "press bureau" utterances condemning municipal ownership and attacking the officials of the National and State governments for "muckraking" and "corporation-baiting" can be traced to men identified with and beneficiaries of just such monumental swindles of the public as the New York City Railway.

Certain it is that the New York City street railway crimes place the strongest kind of argument at the disposal of those who advocate municipal ownership. As it is now, we have municipal corruption and the "shell games" of high finance run in combination. It is difficult to see how any change could be a change for the worse.

The all-too-common lack of accurate information as to the actual quantity of water delivered into their supply mains by American water-works and the even greater uncertainty as to how much of it is lost through leaks have often been discussed in our columns. A small but growing number of works have adopted means for determining with sufficient accurateness the total quantity of water supplied, its division between various districts and between individual consumers. The district consumption, important as a means of locating leaky mains and wasteful consumers, is seldom known except where the supply is divided into districts by local conditions. The Metropolitan Water-Works, supplying Boston and vicinity by wholesale, affords one of the best if not the best American examples of water measurements by sources and districts. The board responsible for that supply has installed a large number of Venturi meters, from the records of which valuable data may be expected. Going as far away as South Africa we find a somewhat similar practice. Some of our readers will remember an outline description of the interesting works of the Rand Water Board, Transvaal, published in our issue of Aug. 2, 1906. This board, through purchase and extension of a number of privately-owned works, now supplies water in bulk to Johannesburg and five near-by municipalities. In a report on operations for the year 1906-7, Mr. D. Leitch, M. Inst. C. E., Chief Engineer of the Rand Water Board, gives a brief description of means employed by that board to record consumption and detect leaks. Monthly tests are made of pump slippage at the main station and of "leakage in the several sections of the mains." For the latter purpose, new mains have been fitted with meters which register both the rate at which water is passing through them and the total volume passed. The supply to Johannesburg is measured by a Venturi meter. As this meter was not constructed for its present position, it is checked from time to time by a weir, provided with an automatic recorder. A further check is afforded by pump records, and a still further one by continuous records of pressure in the delivery main. At other points, 1 to 6-in. Bee meters are used to measure the water delivered to bulk consumers. Four Deacon meters have been set on the distributing mains "to obtain a continuous record of the flow and an indication of the leakage in the different sections." On 14 miles of mains used to collect water from various sources a Cole-Flad pitometer is used at intervals to gain information as to flow and leakage.

These various means of recording consumption, checking pump slippage and detecting leaks in mains are commendable and might profitably be copied, with needed local variations, in all parts of the world, and particularly in water-wasteful America. Aside from water saved by such means there results improvement in pressure, a postponement of the inevitable day when the pumps, supply mains and other parts of the works must be enlarged, and a reduction in operating expenses. Unnecessary pump slippage alone, at many works, means added coal and labor bills the saving of which would alone pay for detecting and preventing not only the slippage but also leaks in the main and the water losses at other points. Until all our cities follow the example of some and obtain water supplies whose purity is above reproach, no reasonable effort should be spared to save water, capital charges and operating expenses, thus making easier the provision of pure water for all. In addition to this important consideration, common prudence and ordinary business methods alike demand that a municipality dealing in water should know how much it receives, how it is distributed, how much is lost en route, and whether every one is paying a proper amount for what he uses and wastes.

Some of the troubles with which engineer and contractor are afflicted in their endeavor to carry an engineering contract to mutually satisfactory conclusion are interestingly presented in the paper of Mr. J. W. Rollins which we reprint on another page, and in the discussion of this paper. Mr. Rollins makes out a strong case against certain clauses that appear in many contracts, both private and public works contracts, though as to some of these clauses he is effectively answered in the discussion. Irrespective of individual clauses, however, there is a distinct flavor, in the article, of a sort of hopeless contradiction between actual and ideal conditions of execution of contracts. This is well exhibited, for example, in those portions of it which relate to changes in plans which may be made by the engineer. The claim is made, on the one hand, that changes in plans—virtually changing the terms of the contract—shou'd be absolutely ruled out, that the engineer should know all the conditions of work and should be sure of just what he requires before the plans and specifications are bid on, and that thereafter the terms of the contract should be as fixed and unalterable as the laws of the Medes and Persians; but when certain things that the contract requires are impossible, or unreasonable, then changes should be made. On the other hand, it is argued that the very flexibility which contractors ask for to enable the engineer to authorize minor departures from the strict terms of the contract, makes it necessary to provide in the contract itself for changes. And the engineers further point out that when under such a clause changes are ordered which involve extra work, the contractor has a legal claim for extra pay. This is perfectly true, we believe, and

it should offer a complete means of satisfaction, to the contractor, for all extra cost resulting from the "as otherwise directed." Unfortunately, two things interfere here: First, the vexations involved in litigation for extra pay; second, certain cunning legal clauses often introduced into contracts, which may suffice to defeat the most just claim for "extra" compensation.

There are in fact many contradictions and conflicts which can hardly be avoided in the performance of a contract. Theoretically, the legal profession has a solution in every such conflict. Practically, recourse to the law is most undesirable and dangerous, and if contracts cannot be carried out without litigation, new forms of contract ought to be devised based more on common sense and less on law; the law being only an ultimate protection. But it happens that many of the conflicts often arising can be settled by the exercise of fairness, a certain ethical common sense. When a contract is let on plans showing solid concrete walls, and the engineer later sketches in "economy holes" which multiply the cost, he displays either ignorance or the instincts of a sharper, in high degree. When a straight lump-sum contract calls for piles driven to firm bottom, and the contractor finds he must drive them deeper than he estimated, he should come up to his agreement manfully, and fairness should prevent him from trying to visit his error on the engineer.

Every engineering contract deals more or less with the unknown, until the work is completed. This can hardly be changed, in spite of Mr. Rollins' demands. In recognition of this, the engineer and the contractor should work together in a spirit of give and take, to secure the desired result without material departure from the cost that could reasonably be anticipated from the advance information. The engineer realizes that additional funds for the work can be obtained only with difficulty, and that the contractor has really bound himself to assume all the chances of the work. But he should also realize that when the chances which do come are quite unexpected and unusual, fairness requires that he endeavor to equalize matters by compensatory modifications elsewhere. And this can be done, in nearly all cases, without affecting the result. The result, be it remembered, is to build certain works, not to carry out a certain legal document; the latter is only a means to the end. But in connection with this matter, Mr. C. B. Dudley's excellent paper, "The Enforcement of Specifications," printed in our issue of July 4, 1907, needs to be read. That paper related mainly to the purchase of material, it is true; structures, such as are concerned in the contracts to which Mr. Rollins refers, are more complex things, and require distinctly less rigidity in the enforcement of the specifications. But the general ideas expressed by Mr. Dudley retain their applicability, and their effect is to modify the amount of latitude which the engineer may exercise in administering a contract.

Without, however, attempting to enter in detail into the many phases of Mr. Rollins' paper, we may properly draw attention to two significant passages. One occurs in Mr. Rollins' closure, and we have there italicized its main part:

> We contractors also know perfectly well that the personality of the engineer can make or break us, and the writer leaves out in this statement any question of actual honesty or dishonesty; that is, in plain words, if an engineer demands in full every and all conditions of the specification to be carried out the job is a failure financially.

This means, if anything, that every contract is underbid; the successful bidder has gambled on doing less than he has strictly agreed "as witness our hands and seals."

The other passage in question occurs in Mr. F. P. Stearns' remarks, and is:

> The writer has yet to know the engineer who, in connection with important work, is able to tell at the time he writes his specifications just what he wants in all details.

These two statements offer much food for reflection. But whatever be thought about them or concluded from them, it is certain that taken together they prove the need for allowing the engineer much latitude in administering a contract. And just as clearly, they prove the need for a very strong sense of fairness on the part of the engineer. Such fairness is not now taught in the schools, neither its essence nor its methods.

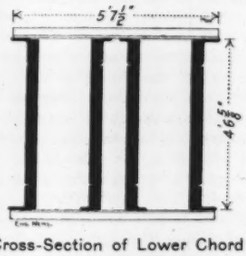
The editors of Engineering News desire to express their sincere gratification for the many letters sent by engineers who have taken pains to express their appreciation of the report on the Quebec bridge disaster published in the issue of Sept. 5.

THE COMPRESSION MEMBERS OF THE QUEBEC BRIDGE

In the discussion which took place among the engineers engaged in the erection of the Quebec bridge, when the bend in the chord member, A 9 L was discovered, it is on record that the foreman in charge, Yenser, was seriously concerned over the condition of the member, while the resident engineer, Birks, thought it a matter of relatively little importance. In the proceedings before the Government Investigating Commission it has been testified that Birks said to Yenser in the course of the discussion: "Why, if you condemn that member, you condemn the whole bridge."

The facts which have been brought to light since the collapse of the structure show that Birks spoke the exact truth. He had confidence in that failing chord because it was to him unbelievable that any mistake could have been made in the design and fabrication of the huge structure over which able engineers had toiled for so many years.

It is plain now that that bend in chord A 9 L did condemn the whole structure, and condemn it not because of weakness in this one member,



Typical Cross-Section of Lower Chord Member A 9 L, Quebec Bridge.

but because it revealed a general weakness in design of all the main compression members—posts and chords alike.

As we stated in our last issue, it has been developed by the investigations of the Government Commission that not only chord member 9 L in the anchor arm, but certain chord members in the cantilever arm had shown signs of distress before the collapse; and that these signs had been noticed as much as three weeks before the disaster. None of the distortions were so serious by any means as the bend in A 9 L; yet looking back now it is easy to see what a grave condition of overstrain they indicated.

In our issue of Sept. 5, immediately following the disaster, we propounded the question, "Were the plates and angles of which these huge compression members were built up, so thoroughly braced together as to make the whole member act as a unit?" In our issue of the week following we called especial attention to the latticing connecting the several ribs or webs of which the column was made up. The valuable contributions discussing the stresses in column latticing which have since appeared in these columns, prepared by engineers in the highest ranks of the profession, have been, we are sure, fully appreciated by all our readers interested in structural designing.

It seems to us desirable, now, to direct attention particularly toward these long, wide and comparatively thin plates, of which the Quebec bridge compression members were made up. Their design has been referred to by several correspondents in this and preceding issues, but we shall attempt to discuss it here in a non-technical way without the use of mathematics, so that the matter may be clear to engineers unfamiliar with structural design.

As we pointed out in this place a week ago, recent computations indicate the probability that these chord members failed under a comparatively low unit load, say 12,000 to 13,000 lbs. per sq. in., much less than was supposed in the collapse first occurred. Where was the weakness in these members that caused them to fail?

If we compare the cross-section of the lower chord Quebec bridge member with a typical compression chord member in a bridge of ordinary size, the most noticeable difference is that the Quebec bridge member is made up almost wholly of plates, while the ordinary member is made up of plates and angles. It was at just this point that the Quebec bridge designers departed from ordinary practice in column design and it is this point, therefore, that new conditions were introduced untested by actual experience.

It is fair to say that this departure was only a step farther than other designers have taken, and the step was made necessary—or seemed to be made necessary—by the enormous loads which had to be carried and the consequent exceptional size of the member. In other large cantilever bridges, such as that at Memphis or the more recent structure at Thebes, Ill., compression members made up of four plate webs have been used, and the proportion of the section of plates to the section of angles in the make-up of these webs is much larger than in ordinary compression members. The Quebec bridge designers merely took another long step in the same direction that others had followed. The four ribs in their design became so broad and thick that the proportion of metal in the flanges of the ribs was insignificant. In fact, it appears to have been the belief of the designer that these composite ribs or webs, each of them about 3½ ins. in thickness, were stiff enough of themselves without riveting on angles other than were required to attach the top and bottom latticing.

This idea can be supported by computation, perhaps, on the theory that if the web is stiff enough not to buckle between the points where it is held by the lacing, then buckling cannot take place at all. Any such computation, however, is based on the assumption that the web 3½ ins. thick is solid metal. Actually, however, the web is not solid metal but is made up of four separate plates held together by stitch rivets. Who is wise enough, now, to say what relation the stiffness of such a composite, built-up plate bears to a solid plate? Without some definite knowledge on this point, how reliable is any computation of the stiffness of these webs?

It is of interest at this point to study the actual behavior of these chords when under stress in the bridge. We are told that on the cantilever arm some of these webs exhibited a slight waviness at certain points. Not all the four webs were affected alike. Some would show an outward deflection; others an inward. Moreover, this extended only a short distance, perhaps only between the points where the webs were held in line by the cross struts of the lacing system. Wherever this waviness occurred, taps with a hammer on the lattice angles indicated that they were under high stress. Further, it is important to note that the top and bottom of a web did not behave alike; the flange angle on top might show a bend outward or inward while the angle at the bottom of the web remained in line.

All this evidence appears to show that these long thin webs which carried compression in the Quebec bridge were *not* stiff enough of themselves, even if the latticing that held them in place had been ample for its work. It may seem misleading to call these huge 3½-in. plates thin; but that they were actually thin in comparison with their great length and width seems clear.

Suppose an engineer were to take one of these big composite plates, 56 ft. long and 4 ft. 6 ins. wide, put it in a testing machine and apply pressure to the opposite ends. It would, of course, buckle to one side or other under trifling load. Suppose, then, we hold it in place by braces at intervals of 6 ft. and continue to apply the pressure; what will happen?

Well, it is clear that the first thing that will happen will be heavy stresses in the bracing that holds this long thin plate in line; much greater stresses than would occur if the plate was stiffened by heavy flanges at top and bottom, to

make it a channel section or an I section instead of a plate.

Suppose, however, the bracing has ample strength and is firmly anchored to supports, what will happen next as the load increases? It requires little familiarity with the behavior of materials under stress to appreciate that the next thing to happen will be a slow incipient buckling of the web at some point between its bracing supports; and this buckling, be it noted, will take place on one side before the other, on the top before the bottom, or vice versa. The reason for this is clear. Even in a testing machine, it will be impossible to apply stress with absolute uniformity to the whole width of a 54-in. wide plate. A mere hair of inaccuracy on one side or other will throw a large excess of compression to one edge and cause buckling to begin there while the other side remains straight—*exactly what happened on some of the chords of the cantilever arm at Quebec as early as Aug. 6.*

It will not escape attention that even with excellent workmanship, absolute accuracy in the bearing of abutting ends of these compression ribs 54 ins. in width could not be expected. On another page of this issue a well known authority on bridge design discusses the influence of such inaccuracy in fit upon the stresses in the chord and we need not refer to it further here.

Suppose now we place a new plate in our testing machine and provide this plate with substantial flanges at top and bottom equal in total cross section, let us say, to one-fourth the cross-section of the plate itself. If we now apply end pressure to this plate (or I-section, as it has now become) it will exhibit considerable lateral stiffness; and when we apply braces as before, to hold it in line it seems certain that these braces will have much less stress with a given load on the column than they carried when the plate without flanges was tested. Further, as the load is increased, it is clear that the flanges will greatly stiffen the edge of the plate and unequal bearing on the ends cannot cause the crumpling of one edge under comparatively light load that took place before.

A question of great interest to designers arises at this point: Suppose we continue to increase the load? Is the great depth of this plate an element of weakness? Can it buckle at the center while the edges are held firmly in line by their flanges? At some point certainly such a mode of failure must be expected. Apply endwise pressure to a broad piece of tin plate, for example, with its edges well supported and stiffened, and it will certainly buckle in the body of the plate. But the webs in the Quebec bridge chord under discussion were 3½ ins. thick. Can we assume that such a plate with its edges stiffened by heavy flanges is as stiff against lateral buckling as a plate of a quarter these dimensions, say 13 ins. wide and ⅞ in. thick? Such plates, and in fact plates of half this thickness or less and of much greater width, are in extensive use in making compression members. We have before us, for example, the make-up sheet of the lower chord of the Thebes cantilever bridge over the Mississippi, composed of four webs each 36 ins. wide and only an inch thick. Whether there were vertical angles or cross diaphragms on these plates to hold them from bulging we are not now informed. Our impression is on the whole that if the separate webs in the Quebec chords had had substantial top and bottom flanges, other stiffening, either by vertical angles or longitudinal diaphragms halfway between the top and bottom, would not have been necessary.

And at this point it is fair to say a word as to the exceedingly difficult problems which the designers of these huge chords for the Quebec bridge had to solve. It is not merely a matter of attaching flanges to the upper and lower edges of these separate webs, but making the section of these flanges effective for carrying compression, not only in the body of the column but at its splices. Difficulties in shop work, in erection, in field riveting, in finding room for the many connections which must be made at panel points—all these and other considerations doubtless had weight in bringing about the final selection of the type of column construction eventually adopted.

As one reads the story of failure of this column in the huge scrap-pile at Quebec and in the reports of initial crippling which occurred before the collapse, it is easy to criticise the design of these chords. But while the great work was going on with apparent success and stability, what bridge designer would have deemed these massive chord members defective? Other features of the design—the high unit stresses in conjunction with comparatively moderate live loads, for example—were much more likely to attract criticism.

It is inevitable, we suppose, that such a disaster as that at Quebec should lead to renewed consideration of the advantages of the circular form for large columns. Some evidences of this have already appeared in our correspondence department. There is no doubt that a flat plate is inherently weak to resist compression as compared with the same plate bent into the form of a circle. But our whole system of bridge construction is based upon the use of flat plates; every bridge structure standing in America is built of such plates. The disadvantage of curved plates, in making connections and in fact at every point in the whole process of production of a structure, from the original outlines on the drawing board to the final completed fabric, is so serious that no one can seriously propose the use of the "Forth Bridge type" of compression members, even for such a monumental structure as the Quebec bridge.

Notwithstanding the dismal wreck on the banks of the lower St. Lawrence, there is no doubt in the minds of the profession as a whole, we take it, that the resources of modern engineering are fully adequate to the task of constructing safe bridges of a span equal to that at Quebec, on the American system of independent unit members built in the shop and erected entire, member by member. There is no necessity for a return to the old European system of building bridges piece by piece in the field.

The Quebec bridge collapse has been an object lesson to every structural designer; and we risk nothing in saying that in a thousand offices, stress computations are being checked over and details of design are being investigated and discussed with greater care and thoroughness than ever before.

Our suggestion as to the need for a larger testing machine to subject some of these modern huge columns to actual breaking load and determine their behavior is receiving hearty commendation from many sources. But as some of our correspondents have well pointed out, full size member tests are only useful to confirm and check our general theory of column strength and of stress distribution in the several parts. We must have sound theory on which to base intelligent design.

LETTERS TO THE EDITOR.

The Chords of the Quebec Bridge.

Sir: In your discussion of the Quebec Bridge disaster, which appeared Sept. 12, it seems to me that you came very near arriving at a clear expósition of the real cause of the failure.

Let us carry out your idea of comparing this column section of 780 sq. ins. with a smaller one, a little more logically, and use a built-up section instead of the two 15-in. channels which you mentioned.

Suppose that we make up a miniature (?) column, to exactly one-eighth scale, and test it to destruction. We would have a column which could readily be tested in any fairly large testing machine, though as a matter of fact its weakness would be so clearly evident as to need no demonstration. My plan is simply to build a column, in which each plate, angle and rivet is made to one-eighth the size in the original column. This column would have an area of 780 ÷ 64 = 12.2 sq. ins., made up of 16 plates about 7 ins. × ⅛ in. and some angles 1 × ¾-in. and 1 × ⅛-in. by less than ⅛-in. thick. The whole thing latticed with angles ½ × ⅜ × 9/64 in. (!!!) and riveted together with say ⅛-in. rivets. The completed column would be about 7 ft. long, and about 7 ins. by 8 ins. in section. You will doubtless agree that this is quite a different thing from two 12-in. channels latticed to make up an equal sectional area.

Is it not quite probable that a small column, made up thus to give correct ratio of length to radius of gyration, would give valuable and perhaps entirely satisfactory evidence under test, of the probable behavior of a very large column which could not be tested directly?

Yours truly,

J. F. Jackson,
Assoc. M. Am. Soc. C. E.

Houghton, Mich., Sept. 21, 1907.

[This striking comparison is subject to a slight allowance on account of the fact that in handling the two columns the large column would not receive proportionately as violent treatment as the small one. No allowance, however, would be necessary if the column were intended for test purposes only; that is, if the miniature heavy column were once properly built, and were mounted in the testing-machine, the possibility of damage in handling would be eliminated as a factor.

The question then arises, how completely would the small column represent the large one, in unit-stress at failure? Is it possible to build the small column so as to offer a fair parallel to the large column? Could we punch ⅛-in. holes in ⅛-in. plate in such a way as to give the same physical results as are obtained in punching 1-in. holes in 15-16-in. plate; and could we drive ⅛-in. rivets of ½-in. grip in any satisfactory manner for the purpose in view?—Ed.]

A Plea for Lower Unit-Stresses.

Sir: On reading in your issue of Sept. 5, the first reliable account of the disaster to the Quebec Bridge, the writer (like Prof. Cardullo, who contributed to your issue of Sept. 19) was immediately struck by the high unit-stresses allowed.

In a climate like that of Quebec, high snow and wind loads combined are bound to occur again and again, all in combination with maximum train loads. In summer the sun will set up expansion in members to which expansion joints cannot be applied. This will, no doubt, produce stresses perhaps impossible to determine. These different factors separately, and some of them collectively, will add stresses to the bridge which cannot be precisely calculated. All this and more Prof. Cardullo has tersely and effectively pointed out.

Again, there seems to have been no provision made for the inevitable increase in weight of rolling stock and motive power which the coming years are to bring, and these loads, moving perhaps at a fairly high speed, must be carried by the bridge.

To a machine designer like the writer, such unit-stresses mean playing tag with disaster. To his non-expert mind, 12,000 lbs. per sq. in. is high enough for any structure carrying a live load. He would prefer 10,000 lbs. per sq. in. for such a large framework as this cantilever, in which as in other such immense structures it is conceded there is no absolute certainty that each square inch of cross-section of metal will get its due share of the load. The above unit-stresses are for medium steel.

Four weeks ago the bridge experts of this country on reading this non-expert opinion on unit-stresses in structural work would probably have smiled that superior smile characteristic of experts when an outsider blunders over the boundary line into their territory. They will hardly be much inclined to smile now.

To the mind of the writer, the worst feature of this affair is not that pile of scrap steel on the St. Lawrence shore, bad though it be; it is the group of poor fellows who were hurled into eternity without even time to cry, "God have mercy on me!" It is the number of bereaved who mourn their loss. Commerce would build twenty such bridges if necessary. It can never replace a single life.

The factor of safety has, perhaps justly, been called the factor of ignorance. If this is true, let us, in the name of common sense, make that factor large enough to cover our ignorance. We are getting altogether too fond of lightness in construction. Let us get back, in a measure at least, to old-fashioned massiveness, even if it does cost a little more.

An old adage says, "It is better to be sure than sorry." Again, we want to do things too cheap (except, of course, in case of a State Capitol), so we rob concrete of its steel and cement, and it comes down about our ears and kills us. In our insane hurry, we won't give concrete time to set properly before we pile more on top of it, hence concrete structures fall, and make work for the trade in rebuilding them, and sometimes, also, work for the undertaker.

Every man who has to do with the design of anything on the strength of which human safety may depend, should hang up over his desk or drawing table a card bearing in 6-inch black letters the two words, "Human Lives."

Very truly yours,

Wm. B. Rainsford, M. E.

Indian Head, Md., Sept. 21, 1907.

The Proportioning of Latticing in Columns.

Sir: Your valued paper has continually given space to the recording of great and lamentable disasters to engineering structures. Much valuable criticism followed, and great advancement was made thereby in the knowledge of engineering designs and structural materials.

Cast-iron columns have fallen and killed many; criticism followed, condemning cast-iron construction in skyscrapers. Highway bridges have gone down; it was said that the "Highwayman" took everything but the coat of paint. Reinforced concrete has failed, and invariably it was laid to poor design or faulty construction. Now we have recorded perhaps the greatest disaster known in the history of structural engineering, and the trend of criticism seems to be toward the fact that we, as engineers, are ignorant in column theory.

Many persons are calling for tests of large columns. The writer, too, hopes that such tests will be made. But are we to infer that such tests alone will reveal to us the size of batten plates, lacing and rivets required? Such tests can only corroborate our present knowledge of column action. Commentators on the Quebec Bridge disaster imply that our knowledge of column lacing is very limited, and that in moderate-sized columns the lacing has been determined by "rule of thumb." The writer wishes to take the position, and will attempt to show that we do know something about designing lacing, and that theory and methods as accurate, practical and scientific can be applied to the lacing as to the main members of the column.

The theory of flexure has developed many formulas; subsequent tests have corroborated and simplified such formulas, until to-day we have the simplest form in the straight-line formula. We have the formula for stress due to eccentricity:

$$S = \frac{M n}{I} = \frac{p A c n}{A r^2} = \frac{p c n}{r^2} \quad \therefore e = \frac{S r^2}{p n}.$$

Using Cooper's chord formula as a representative straight-line formula,

$$p = 20{,}000 - 90\frac{l}{r}, \text{ and } S = 90 - \frac{l}{r}.$$

$$\therefore e = \frac{\left(90 - \frac{l}{r}\right) r^2}{\left(20{,}000 - 90\frac{l}{r}\right) n}$$

Where l = length in inches;
r = radius of gyration in inches;
n = distance from center of gravity to outer edge;
S = stress caused by moment M;
I = moment of inertia;
e = eccentricity of column at the middle of its length.

This formula gives us the eccentricity in any column where Cooper's formula applies in terms that are known. It is not known just where this eccentricity takes place. It may be near the end of the column or it may have an increasing value toward the middle of the column. It may be a combination of these two cases, part at the ends and part increasing toward the middle. If the column is designed to take all of the moment due to eccentricity at the end in a distance equal to the width of the column, and the remainder of the column is also designed to take all of the moment as an increment, the column would then be built on the side of safety.

Chord A9 in the Quebec Bridge has the following properties:

l = 684 ins.
A = 780 sq. ins.
r = 19.5 ins. (about vertical axis).
I = 299,000 ins. (about vertical axis).
n = 30 ins. (about vertical axis).

And therefrom

e = 2.37 ins.

It has been stated that A9 at the time of failure sustained a load of 16,000 lbs. per sq. in., making a total load of 12,480,000 lbs., and a moment due to eccentricity of 29,600,000 in.-lbs. From this we calculate the shear per lineal inch in the end section as

$$\frac{29{,}600{,}000}{60 \times 60} = 8{,}200 \text{ lbs.},$$

which must be taken care of by the lacing at the ends. Assuming a rivet value of 6,000 lbs., it will be necessary to space the rivets top and bottom not over 1½ ins. apart for the first 60 ins. from the end. The possible shear in the half length of the column would be, per lineal inch

$$\frac{29{,}600{,}000}{28 \times 12 \times 60} = 1{,}475 \text{ lbs.},$$

assuming that the eccentricity increases as the distance from the end. In a lattice panel 6 ft. long, such as in A9, and with a rivet value of 6,000 lbs., nine rivets are required at top and bottom in the chords and 14 in the diagonals, whereas the drawing shows only four.

It may be thought that such large eccentricities will hardly ever obtain in actual practice. A few cases have been worked out and their results are given below:

(a) If twenty rivets do not completely fill the holes on one side of a vertical axis in A9, e = 1½ ins.

(b) If the pin-holes are bored 1-64-in. larger on one side at each end, e = 1 in.

(c) If paint or buckles in the plates pack out one side of the chord ¼-in., e = ⅛-in.

When it is known that the best of shopwork will produce eccentricities of such magnitude, it is necessary to take care of it in a rational, scientific and practicable manner.

Yours very truly,

A. M. Meyers,
Kansas City Structural Steel Co.

Kansas City, Mo., Sept. 21, 1907.

[It is necessary to observe that neither theory nor practice, as now current, recognize the existence of eccentricities in columns, or, to state it more correctly, recognize that the use of a column formula implies a tacit admission that eccentricities do exist. We discussed this subject at some length in our issue of Jan. 3, 1907, under the heading "Column Formulas in Relation to the Practical Column," and showed (for the first time, we believe) that a definite, calculable eccentricity is premised by every column formula.

When a column has deflected a given amount, shearing stresses exist in its web-members. The total shear is equal to the direct compression multiplied by the tangent of the angle which the column axis at the point considered makes with the straight line joining the ends of the columns, that is,

$$\text{Shear} = \text{Column Load} \times \frac{dy}{dx}$$

In a column with a full web, or with a true web system, this shear exists in the web-system, neutralizing the transverse component of the stress in the main members, which latter have no shear. In the objectionable style of columns which has only batten plates connecting the main members, the shear exists in the main members only, being transferred across at the bottom plates. In either case, it is a definitely calculable quantity, from which the stresses in the web can be calculated.

A column is not meant to buckle, of course. The bent chord A9L, with its deflection of nearly 2 ins., carried a stress in its lattice system which reached close to the ultimate strength of the lattice-riveting, and probably not far from the ultimate strength of the compression members of the lattice. But this was an emergency condition, not a condition which was intended or could be foreseen. We have as yet no explanation of how the column could acquire this bend, except on the assumption that it had an initial "equivalent eccentricity" of about 1½ ins. But if that chord were truly straight, homogeneous, and its load central, there would be no stress in the lattice.

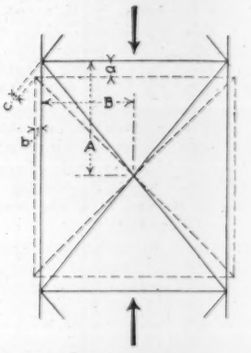
If, in designing a column, we recognize an "equivalent eccentricity" by using a column formula to fix the required section of main members, why should we not also recognize the possible existence of eccentricity in designing the web of the column? The computations made in the above letter illustrate how this would be done. Elsewhere in this issue Mr. H. S. Prichard discusses the effect of imperfect butt joints in columns and calculates the stresses due to this effect under certain conditions assumed as probable. Such conditions are, of course, intended to be included in the "initial eccentricity." If the column formula employed does not make adequate allowance for such imperfections, the formula must be modified by a greater reduction-factor.

The subject is interconnected, moreover, with the argument presented on our editorial page, namely, that heavy columns should not be built with so much concentrated metal-area that their component parts will be lacking in inherent lateral solidity or rigidity. The point of this is that if the individual parts of a column are too "ribbony," it will be practically impossible to build them up into the finished column without exceeding the ordinary allowance for eccentricity, i. e., requiring a much greater column reduction factor.—Ed.]

Compression Carried by Lattice Members of Columns.

Sir: The following is offered in the hope of contributing a little to the problem of latticing compression members.

The accompanying diagram of a short section of a heavy compression member, such as the lower chord of the Quebec Bridge, shows the distortion of the latticing which must take place in a perfect, centrally loaded, symmetrical strut with cross-ties between the two systems of diagonals; the dotted lines indicate the positions of the parts when loaded.



$$A^2 + B^2 = C^2.$$

$$(A - a)^2 + (B + b)^2 = (C - c)^2.$$

Or, ignoring the squares of the very small changes of lengths (a^2, b^2 and c^2),

$$A^2 - 2Aa + B^2 + 2Bb = C^2 - 2Cc.$$

Subtracting,

$$-2Aa + 2Bb = -2cC.$$

Or, for 45° lattice,

$$a - b = 1.4c \quad \ldots\ldots\ldots\ldots (1).$$

Let S_a be the unit-stress in the column itself, S_b and S_c the unit-stresses in the lattice members; then $a = A S_a/E$; $b = B S_b/E$; and $c = C S_c/E$. Substituting in (1), we have

$$\frac{A S_a - B S_b}{E} = 1.4 \frac{C S_c}{E}.$$

Divide by A (= B) and multiply by E, then

$$S_a - S_b = 2 S_c \quad \ldots\ldots\ldots\ldots (2).$$

At Quebec,

$$\frac{\text{Net area } B\ [3\frac{1}{2} \times 3\frac{1}{2} \times \frac{7}{8}\ L]}{\text{Gross area } C\ [4 \times 3 \times \frac{7}{8}\ L]} = 4/5 \text{ (approx.)}.$$

$$\frac{\text{Total stress in } B}{\text{Total stress in } C} = 1.4.$$

$$\therefore \frac{\text{Unit-stress in } B}{\text{Unit-stress in } C} = \frac{1.4}{4/5} = 1.75 = \frac{S_b}{S_c}.$$

This makes possible the elimination of S_b from (2), giving $S_a = 2 S_c + 1.75 S_c$, or $S_c = \frac{S_a}{3.75}$.

That is, the unit-stress in stiff diagonal lattice members intersecting at right angles and tied together at their ends is 27.6% of the unit-stress in the column, even though the strut has no deflection or eccentricity.

In chord section A9 of the Quebec Bridge, the dead and live unit-stress (S_a) was $\frac{15{,}268{,}000}{781} = 19{,}600$ lbs. per sq. in., without wind. Then $S_c = 19{,}600/3.75 = 5{,}200$ lbs. per sq. in., or a total stress in C of 13,000, just about the total allowable load on the two rivets used, leaving nothing for the proper work of lattice in resisting bending.

If the cross-ties B were omitted this stress would not exist.

Referring to sketch of A9L, p. 264, Engineering News of Sept. 5, the bend seems to have been at least 1½ ins. in a length of three lattice spaces each side of center. The compression stress on Aug. 28 being taken as 10,000,000 lbs., the moment was 15,000,000 in.-lbs. At least 95% (say 14,000,000) must have been resisted by the outer web, with lever arm of 52 ins., giving a stress of 280,000 lbs. That stress must have been received from at most eight lattice-bars, therefore one component (7/10) of the stress in each lattice-bar was 32,500 lbs., or the stress on each rivet = 10/7 × 32,500/2 = 23,200 lbs. due to bending, and at least 5,000 lbs. more due to the effect of the cross-ties noted above.

The calculation of the lattice stress due to the bending found Aug. 26 or 27 should have taken any engineer but a few minutes, and should have convinced every one interested that the immediate requirement was a temporary strut to the intersection of the bottom laterals, to prevent further deflection of chord, to save the bridge and to save the reputation of the profession.

Yours truly,

John Bartholomew.

61 West 12th St., New York, Sept. 23, 1907.

The Quebec Bridge Disaster.

Sir: The engineering profession, as a whole, very certainly owes to your journal and its editorial staff a vote of thanks for the wonderful way in which you have written up the great Quebec Bridge disaster; but I am under the impression that yourselves, and doubtless almost everyone else, has overlooked the fact that exactly this same lesson was taught to the engineering profession on the evening of Friday, Sept. 29, 1876, when the Ashtabula Bridge, on the Lake Shore Ry., in Ohio, went down, causing great loss of life, and causing the engineering profession consternation equally as great as, if not greater than, has been occasioned by the disaster at Quebec.

Boiled down, that failure was the result of an attempt on the part of the then Chief Engineer of the road, Mr. Charles Collins, to design a Howe truss bridge of metal. In carrying out this design, the compression members were made by using in the top chord five lines of 6-in. I-beams, and from two to six beams for the diagonal posts. These I-beams were not sufficiently fastened together in detail to carry the loads, and the bridge failed by reason of the I-beams acting separately instead of acting together as one member, exactly as was the case of the member A9 in the Quebec Bridge.

The writer feels fully justified, therefore, in taking exception to your statement that we in the engineering profession have not sufficient data on the strength of columns to take care of the design of such large compression members as were called for in this bridge.

On the evening of Sept. 7, after very meager accounts had been read in the newspapers with regard to the Quebec disaster, and before any accounts had been received here through the engineering papers, the writer gave a talk before a meeting of the Pacific Northwest Society of Engineers, and illustrated the progress of the erection of the Quebec Bridge by enlarged photographs by means of a reflectograph, which utilized the illustrations in a small pamphlet on the Quebec Bridge which was received at my office a day or so after the bridge fell down. One of the things that was particularly impressive in seeing these pictures on a screen was the design of the huge posts, some of which were lying down on the cars before erection, and the writer called attention to the fact that for the amount of material in the posts, the columns had a very small radius of gyration, and that, had the designers taken a lesson from nature, as taught by the wheat straw, and the object-lesson of similar members on the Forth Bridge, very much stronger members could have been designed with considerably less metal.

We can say what we like about the English and Continental bridge designs, but we must admit that when it comes to cases out of the ordinary their methods of design are much superior to our own.

The Knoxville cantilever bridge, over the Tennessee River, built by the writer, while not of long span, is one of the heavy cantilever bridges, and the detail calculations on this were made by the writer's then assistant, the late Professor A. H. Heller, of the Ohio State University, and checked up by the Inspector's engineer, Mr. Edward Godfrey. Many of the same problems that came up in the Quebec Bridge design were discussed at that time, and I do not believe that had Prof. Heller been called upon to meet such conditions as are called for in as large a bridge as that under discussion, he would have failed to catch the points in the design which seem to have caused failure.

The question occurs to any one in studying the situation: Why were the compression members not designed of tubular form, or else designed with horizontal diaphragms to take up the enormous transverse stress that could be set up, and that was set up, by the deflection of one of the members? At any rate, had the outside webs been designed with outside and inside flange angles, thus assuring plenty of room to which the lacing angles could have been riveted, it is pretty certain that the failures would not have taken place.

Another question that then occurs is, why were only two rivets put in the ends of the lacing angles? One of the axioms of good bridge design is that *two rivets do not make a connection*, inasmuch as when one of the rivets becomes loose and all the stress is thrown on the other, then it is pretty sure to give way as well; whereas with three or four rivets to take up the actual or estimated stress, the connection will be found perfectly safe in practice.

The question also arises, why didn't the designers endeavor to approximate the stress on these lacing angles by means of Euler's formula, or by comparison empirically with the data at hand of columns that had failed in testing, through the failure of details, as this is the usual method of the failure of columns.

Here again it is the writer's opinion that very much of the detail work on the theory of columns has been lost to the profession by being published in obscure reports; and I am under the impression as well that the investigation made and published in the report of the Railway Commissioners of Ohio in 1885 contains data that would enable a designer to fully meet the conditions which caused the failure of the columns of the Quebec Bridge, although doubtless many of our other books and reports would be equally conclusive on this important matter.

Another question that will doubtless be asked sooner or later, and which is of great interest to the engineering profession, is: Why was the width of this bridge only 67 ft. center to center of trusses? On the Forth Bridge, the width between trusses at the base of the towers is 120 ft., the towers being practically the same height as those at Quebec. Using the old rule of thumb would require the width of the bridge to be not less than 1-20th of the span, and would have called for a width at the towers of 90 ft. While doubtless the fact of this span being a cantilever would be sufficient reason for reducing the effective width, the writer cannot believe that a width of much less than 90 ft. would be safe for so great a span, and preferably a bridge of this kind should have a tower in the other direction, longitudinally, of at least an equal amount; although in the Forth Bridge the dimensions of the towers longitudinally were 155 ft. for the shore towers, and 270 ft. for the Inchgarvie.

Again we may ask, why was such a topheavy traveler designed for the work of erection? Could it not have been done almost equally as well with a smaller traveler, such as was finally erected for finishing up the suspended span?

Upon mature consideration one cannot help but feel that this topheavy traveler, combined with the small width of the bridge, must have had considerable effect upon the failure of the bridge.

The question of riveting must also have had considerable to do with the failure, especially as it would seem from the reports that much of the riveting in the vicinity of the badly crippled member was still incomplete.

If we mistake not, one of our large bridge companies has had a large number of large bridge failures in the past twenty years, which were more or less due to the lack of sufficient riveting having been done. Would it not be well, therefore, to make it a rule to fully rivet up the joints in all large bridges before proceeding very far in advance with the erection?

The writer would not, therefore, feel that we have reached a point where it is necessary to call a halt in our engineering construction because of lack of data from which to make up our designs; but it is certainly wise to take advantage of all the information that has come down to us during the years gone by, from various successes and failures, to make sure of the various steps in the designing and construction of our great bridges.

Right here it might not be amiss to sound a note of warning with reference to the concrete-steel constructions that are now being foisted on a believing public. In very many cases concrete-steel construction is being used where older types of solid construction would be very much cheaper, and in many cases construction of this kind is being used of such extreme lightness in detail, and with such overawing faith in the strength and co-operation of the materials employed, that disaster must ensue sooner or later with great loss of life, and with great shame to the engineering profession.

Yours truly,

Charles Evan Fowler,
M. Am Soc. C. E.;
M. Can. Soc. C. E.

Seattle, Wash., Sept. 21, 1907.

[Prof. A. H. Heller is also to be remembered as having given in his work "Stresses in Structures," left uncompleted by his death and recently published, a more illuminating treatment of columns than can be found in other works on applied mechanics. The subject of eccentricity, and stress resulting therefrom, is very clearly presented, and the relation between the Rankine formula and the stresses due to eccentricity is indicated. Prof. Heller is therefore one of the pioneers in an advance which will doubtless be embodied in all courses of Applied Mechanics in the future.—Ed.]

The Quebec Bridge Disaster: The Make-Up of the Chord Members.

Sir: By the fall of the bridge at Quebec has come to all engineers, and particularly to those who make the design of bridge and structural work a specialty, a great affliction which would incline us to withdraw from the eyes of the world until we can regain our composure. We should naturally refrain from saying a single word, except that we would express our condolence with those who are the chief mourners; and especially do we wish to show our sympathy with that Nestor of American bridge engineering, who may be feeling that this accident comes as a hot blast to turn to ashes the chaplet of roses which engineers and the whole world have placed upon his brow.

However, it behooves us to study carefully the lessons to be learned from this accident, that we may be the better able to design safely in the future.

With the great skill and thoroughness which always characterize its investigation of such accidents, Engineering News has given to its readers with remarkable promptness a full account of the facts in the case, and has pointed out, not only the source of initial failure, but the primary cause of the weakness of this member.

It would seem to the writer that the accidents to which the member designated as A9L has been the victim may have had a more important bearing on the case than has generally been credited to them, and that there are other portions of the bottom chords of the bridge which under the same conditions would be fully as weak as the portion where the failure seems to have begun.

It is reported that the member had been perfectly straightened, and I have no doubt that this is practically the case; but *after the straightening process were the planed ends and the pin-hole perfectly normal to the axis of the member*? The reported buckling of this section of the chord would certainly suggest a possibility that one of the ends or the pin, or perhaps both, may have been left at a slight angle with the intended position, causing an eccentricity of strain which would have been absent had there been no previous accident to the member. When one sees the adjustment of a milling machine for planing the ends of a column, and realizes the importance of perfection in its work, one cannot but be impressed with the delicacy of its adjustment. The column may be tested after the ends are planed; but the ordinary methods of testing this normality are crude compared with the delicacy with which the machine may be set. Very likely no greater care was taken in testing the ends of A9L, or its pin-hole, after it was repaired than is exercised on new work at the shop—if indeed any test at all was made. The writer would be loath to blame any one for this neglect, if there was such, for there is much truth in the old proverb, "hindsight is better than foresight," and at that time no hand was pointing so plainly as now to the question as to its condition.

You have called attention to the weakness of the latticing so forcibly, and others have said so much about this feature, that the present writer will refer to it only to express his recognition of this weakness and his belief that it was an important contributing factor in the accident and one whose seriousness would be greatly emphasized by an abnormality in the ends or pin-hole as above suggested.

Another factor of weakness in the make-up of this chord (which apparently had only a minor part in causing the sad result, but which might have proved of great significance had not other causes brought about destruction) seems to have been generally overlooked. In the panel of the bottom chord of which A9L forms the larger part, the ratio of unsupported length to least radius of gyration about the horizontal axis of the whole member is 42.3, and the ratio of this length to the radius about the vertical axis (the way in which the member failed) is 34.6. But in considering each web of this member by itself, there is a ratio of 52.0 for the clear depth of web between the insides of horizontal legs of angles (i. e., between the points of support if the latticing were thoroughly efficient) to the radius of gyration of the same portion of the web; and the ratio of length of lattice panel to the radius of gyration of the outer webs appears to be about 52.2 (though the exact length of lattice panel is unknown to the writer). This excess of ratio of unsupported length to the least radius of gyration for the details, as compared with the similar ratio in this member as a whole, is not so great as to be alarming in the thought of its possible effect upon the strength of the member, but is contrary to the principle expressed in the common and wise specification that no detail shall be weaker than the body of the member. Probably the ratio for the member as a whole was used in determining the allowable unit stress. But the bottom chord in the panel next to the anchor pier has a ratio of 154 for the depth between the inner rows of rivets compared with the radius of gyration of the unsupported web. The webs in this panel of chord are stiffened by vertical angles; but the spacing of stiffeners is so great that the unsupported length of web exceeds its unsupported depth. If this ratio of 154 were used in determining the allowed unit stress with the same formula as is given for proportioning main posts, the allowed stress would be reduced to 36/100 of that specified for compression chords where l is less than 50 r.

Your suggestion is a good one, that tests should be made of full-size compression members of large proportions both as to cross-section and length. Such tests might fortify us in our judgment, but it is doubtful whether any wonderful information would be gained by them; for it is hardly probable that the principles governing such members under compression are different from those we now know, or that the formulas now in use would be greatly modified by such tests. The difference found between results of full-size and specimen tests in timber is no criterion for the value of the suggested tests of large steel compression members because steel is a homogeneous material. Is not the question

presented to us by the Quebec disaster one of distribution of the stress and its abnormality or eccentricity rather than of the difference in the action of large and small members? If we could know exactly the eccentricity of the compressive force in the member as a whole and its distribution and eccentricity in the constituent parts, could we not predict very closely what would be the result in the way of buckling of the member as a whole and of each web thereof, and also the strain upon the latticing? It would seem to the writer that if such full-size tests of large members should be made as suggested, by subjecting them to compression sufficient to cause their failure, it would be well at the same time to measure the comparative intensity of strain in different parts of its cross-section and length by the thermo-electric method described to the American Society of Civil Engineers a few years ago by Mr. C. A. P. Turner. In this way we may gain valuable information as to the distribution of stress and the effect upon that distribution by variations in the total stress.

Herbert C. Keith.

116 Nassau St., New York City, Sept. 23, 1907.

Should the Bridge Contractor Make the Detail Designs?

Sir: Referring to the recent Quebec Bridge disaster, a feature of the methods employed, namely, the fabricators of the bridge designing the structure (which I understand was the case), is one that is open to some criticism. I understand bids are asked for a bridge of a certain general design, and it is then up to the successful bidder to design the bridge in detail. Without any comment on this particular case, does it not seem natural from a business standpoint that a bidder would design a structure containing the minimum amount of material? Would it not be better for an engineer to design the bridge in detail and to receive bids for the construction according to these plans?

Yours truly,

Herbert M. Rosenberg,

Assoc. M. Inst. M. E.

555 West 33d St., New York City, Sept. 23, 1907.

[In theory, yes. In practice, no. We do not know of an engineer in private practice who has the organization to make complete detail shop drawings for such a structure as the Quebec Bridge and do the work with anything like the efficiency of the designing staffs of the great bridge companies. For one thing, the designs for any such structure must be worked out in cooperation with the shop and with the rolling mills. In other words, the engineer must make a design which the shop can construct and which the erecting force can put in place in the field.

The independent engineer has his function in fixing the specifications and general designs for the structure and in checking over the work of the bridge company's engineers and constructors to make certain that no error has been made at any point and the specifications have been fulfilled.

We may note that the same rule applies to practically all lines of engineering work in which modern manufacturing methods are employed. Ships, locomotives, engines of all classes, electric generators and motors, all have their shop drawings made and their details of construction determined by the manufacturer who builds them.—Ed.]

A Tornado the Cause of the Lacrosse Chimney Collapse.

Sir: The report in your issue of Sept. 5th, describing the destruction of one of our chimneys at La Crosse, Wis., has been read by us with interest, and we beg to make some corrections concerning the statement made by Mr. Miller.

Mr. Miller says the U. S. Weather Bureau in La Crosse has a record of a northwest wind with a maximum velocity of 60 mi. per hour. He further states that a southwest gale stronger than the northwest met the same in La Crosse, and the chimney fell in a northeasterly direction. It seems to us that in view of such information, and knowing that a northwest wind would not throw the chimney in a northeasterly direction, Mr. Miller could have obtained sufficient information from experts by which he would have learned that when two opposite gales of the velocity as described meet, they will invariably form a vortex, the existence of which is fully indicated in the report of the La Crosse Weather Office, which describes the path of the storm as not extending in places over more than three blocks.

When by the foregoing facts the existence of a tornado can be firmly established, we insist that the chimney was not blown down, as asserted by Mr. Miller, but was twisted from its base, pushed through the wall, and carried about 10 ft. away before being allowed to fall into the street, only the top part being crushed by the fall.

The step irons, which were located on the northwest side of chimney, appear on the picture in the northeast side. This conclusively proves our claim, as in a straight blow down they would not be visible.

We would further add that if a general wind had prevailed of the velocity that threw down the chimney and a 20-in. wall, uprooted trees, turned the cupola of a building completely around without removing it, not a building in La Crosse would stand to-day.

The construction of our chimney, which has been approved by the foremost talent in the engineering profession, had been carried out in accordance with plans and specifications in every detail, and no clamping of rods, nor increase of cement (the concrete was mixed in a proportion of one to three), would have made the slightest difference when the irresistible force of such a storm is taken into consideration.

The fact that we are rebuilding the chimney under the same specifications furnishes sufficient proof that the owner and their engineer have unlimited confidence in our construction.

Yours truly,

Atlas Construction Company,

By F. Wiederholdt, Secy. and Treas.

American Trust Bldg., Chicago, Sept. 20, 1907.

IMPERFECT BUTT-JOINTS IN COLUMNS, AND STRESSES IN LATTICE-BARS.

By HENRY S. PRICHARD,* M. Am. Soc. C. E.

Imperfect butt-joints between the ends of columns will produce bending stresses which should be considered in designing, especially where very large latticed columns far beyond the range of previous experience and tests are concerned.

As a basis for making an analysis of bending stresses so produced, the following general formula for deflection is quoted from the ordinary theory of flexure. To find the deflection of any point in the axis of a beam of constant cross section with reference to a tangent through a second point:

In Fig. 1, let Δ = the deflection.
D = the area of the moment diagram.
I = the moment of inertia of the cross section of the beam.
E = the modulus of elasticity of the material.
n = the distance from the center of gravity of the moment diagram to the point whose deflection is sought.

Then
$$\Delta = \frac{D n}{E I} \qquad \ldots\ldots (1)$$

Conceive a line of three equal symmetrical columns composed of channels latticed, the middle column originally tilted and the end columns parallel to each other, as shown in Figs. 2 and 3.

Let l = the length of each column.
a = the angle of tilt.
d = the distance from the axis of the column to the line of thrust at sections B and D.
W = a load just sufficient to bring the channels into contact at R and L, but with zero stress at these points.
P = the transverse forces developed at A and E.
S = the shear in the middle column.

Under these forces the three columns form a single elastically continuous member.

PROBLEM I.—To determine the values of P and S when the load W acts at points A and E without eccentricity and the columns are held against lateral movement at points A, B, D and E but are free to pivot at A and E (Fig. 2).

The moment at points A and E is zero.

The moment at the center (point C) is zero.

The shear from A to B and from E to D is P, and between B and D is S.

The forces acting on the abutting surfaces at column-ends D and B are the shearing forces P and S, and the compression W acting normal to the surfaces with center of action at a distance d from the axis of the column.

*Beaver, Pa.

From the foregoing considerations the bending moment at points B and D can be expressed in a number of ways and equated as follows:

Taking moments around B, either for the column BA or the half column BC,

$$W d = S \frac{l}{2} = P l \qquad \ldots\ldots (2)$$

Hence
$$W = \frac{S l}{2 d} \qquad \ldots\ldots (3)$$

and
$$P = 0.5\ S \qquad \ldots\ldots (4)$$

Neglecting the slight moment of W, at points between A and B, due to the curvature of BA (a secondary moment), the area of the moment diagram between points B and A or D and E

$$= \frac{S l^2}{4} \qquad \ldots\ldots (5)$$

The area of the moment diagram between points B and C or C and D

$$= \frac{S l^2}{8} \qquad \ldots\ldots (6)$$

By the formulas for beam deflection, or by Eq. (1), the deflection of point D relative to a tangent to the axis at C is

$$\Delta_1 = \frac{S l^3}{48 E I} \qquad \ldots\ldots (7)$$

As the sketch Fig. 2 shows, the deflection of E from the tangent at C is $3\Delta_1 + l \tan a$. Expressing this same deflection in terms of the moment diagram, by Eq. (1), we get

$$\frac{S l^3}{6 E I} + \frac{7 S l^3}{48 E I} = l \tan a + 3 \Delta_1$$

And using the value of Eq. (7),

$$\frac{15}{48} \frac{S l^3}{E I} = l \tan a + \frac{3 S l^3}{48 E I} \qquad \ldots\ldots (8)$$

from which is found

$$\frac{S l^3}{4 E I} = l \tan a$$

$$S = \frac{4 E I \tan a}{l^2} \qquad \ldots\ldots (9)$$

PROBLEM II.—To determine the values of P and S when the columns are held laterally at B and D and have fixed ends at A and E; that is, at A and E the ends are held against both lateral and rotary motion (Fig. 3).

The moment at the center (point C) is zero.

As in Problem I. and for the same reasons the moment at B and D is

$$W d = \frac{1}{2} S l \qquad \ldots\ldots (10)$$

Whence
$$W = \frac{S l}{2 d} \qquad \ldots\ldots (11)$$

The moment at A and E is

$$M_1 = P l - \tfrac{1}{2} S l \qquad \ldots\ldots (12)$$

As the column is fixed at E and held laterally at D, a tangent to the axis at E will pass through D, therefore the deflection at D relative to a tangent to the axis at E is zero.

The deflection can also be expressed by means of the moment diagram and Eq. (1), which when equated to zero gives

$$P l \times \frac{\frac{l}{2} \times \frac{2 l}{3}}{E I} - \frac{0.5\ S l \times l \times 0.5\ l}{E I} = 0 \qquad \ldots (13)$$

Whence
$$\frac{P l^3}{3} = \frac{S l^3}{4}$$

or
$$P = \frac{3 S}{4} \qquad \ldots\ldots (14)$$

The deflection at C relative to a tangent to the axis at E evidently equals $\frac{1}{2} l \tan a$; equating this to the deflection expressed in terms of the moment digram,

$$\frac{0.5 S l \times \frac{1}{2} \times l}{E I} + \frac{0.5 S l \times \frac{l}{4} \times \frac{l}{3} - P l \times \frac{l}{2} \times \frac{7 l}{6}}{E I} = \frac{l}{2} \tan a \quad \ldots\ldots(15)$$

Substituting the value of P from Eq. (14) gives

$$\frac{5 S l^2}{24} = E I \tan a$$

or

$$S = \frac{4.8 E I \tan a}{l^2} \quad \ldots\ldots(16)$$

PROBLEM IIII.—To find the value of W:

Let v = half the width of the column.

I_1 = the moment of inertia of the cross-section, about an axis through R or L (Figs. 2 and 3).

The intensity of the stress will vary from zero at L to $\frac{2W}{A}$ at the opposite side of the column, as shown in Fig. 4 (the column being assumed symmetrical about its gravity axis). The moment of the stresses at this section about point L is $\frac{I_1 W}{A v}$. The line of thrust is distant d from the center of the column, and its moment around

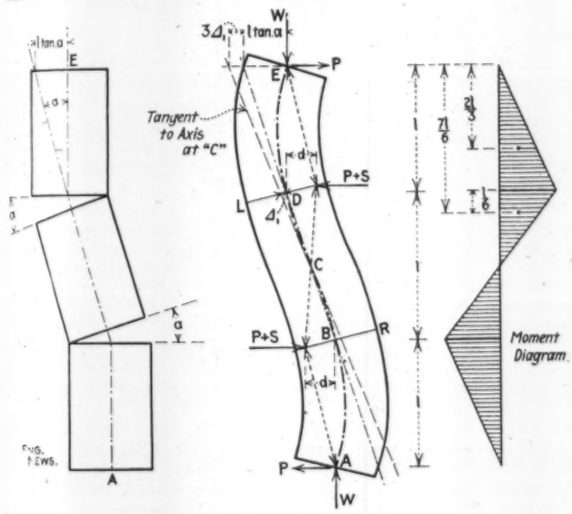


Fig. 2.

L is $W(v + d)$. Then as these two moments must balance,

$$W(v + d) = \frac{I_1 W}{v A} = \frac{(I + A v^2) W}{v A} \quad (17)$$

Reducing, this gives

$$d = \frac{r^2}{v} \quad \ldots\ldots(18)$$

Substituting this value of d in Eq. (3) or (11),

$$W = \frac{S I v}{2 r_2} \quad \ldots\ldots(19)$$

which applies to the conditions stated in both Problem I. and Problem II.

PROBLEM IV.—When a column is latticed with two systems of diagonals and in addition has transverse members or ties at the panel-points of the latticing, the effect of the ties will be to force the diagonals to take part in the shortening of the main members, and therefore to take part of the compressive stress in the column. This is illustrated by Fig. 5, which shows a panel of an unstrained column, in full lines; and the same panel strained, in dotted lines. Enlarged details to the right and left show the changes in length from strain.

To determine the compressive stress carried by the latticing from this cause, let

b = the angle which the lattice bars make with the axis of the column.

h = the panel length of the latticing.

f = the compression per square inch in the column.

x = the compression per square inch in the lattice-bars.

t = the tension per square inch in the cross-ties.

B = the cross-sectional area of each lattice-bar.

C = the cross-sectional area of each cross-tie.

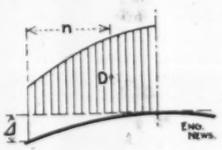


Fig. 1

Length of lattice-bars

$$= \frac{h}{\cos b} \quad \ldots\ldots(20)$$

Length of ties

$$= h \tan b \quad \ldots\ldots(21)$$

The shortening of the channels

$$= \frac{f h}{E} \quad \ldots\ldots(22)$$

The lengthening of the ties

$$= \frac{t h \tan b}{E} \quad \ldots\ldots(23)$$

The shortening of the diagonals

$$= \frac{x h}{E \cos b} \quad \ldots\ldots(24)$$

From the geometrical relations shown by the detail sketches in Fig. 5 we find

$$\frac{x h}{E \cos b} = \frac{f h \cos b}{E} - \frac{t h \sin b \tan b}{E} \quad \ldots\ldots(25)$$

$$\therefore x = f (\cos b)^2 - t (\sin b)^2 \quad \ldots\ldots(26)$$

Fig. 4.

The transverse components of the stresses at a panel-point give the equation

$$2 x B \sin b = t C \quad \ldots\ldots(27)$$

from which

$$t = \frac{2 B}{C} x \sin b \quad \ldots\ldots(28)$$

Substituting this value of t in Eq. (26),

$$x = f (\cos b)^2 - \frac{2 B}{C} x (\sin b)^2$$

and this gives

$$x = \frac{f (\cos b)^2}{1 + \frac{2 B}{C} (\sin b)^3} \quad \ldots\ldots(27)$$

For $b = 45°$, this formula shows that

$$x = \frac{f}{2 + \frac{B}{C}\sqrt{2}}$$

For $b = 45°$, lattice bars $4 \times 3 \times \frac{5}{16}$-in. angles, and ties $3\frac{1}{2} \times 3 \times \frac{5}{16}$-in. angles,

$$x = 0.284\, f.$$

PROBLEM V.—To determine the values of S and P under the conditions of practice.

From equations (9) and (16) it appears that the value of S does not differ greatly, whether the ends of the columns are free to turn at A and E without developing bending moments at these points, as in Problem I., or fixed, as in Problem II. In practice the ends are usually somewhat restrained from turning; that is, they are partially fixed, which will give a value for

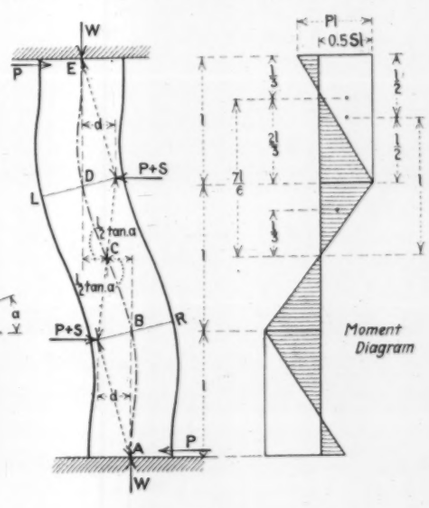


Fig. 3.

S greater than when the ends are free to turn, and less than when fixed. Under the conditions of Problem I., P equals $\frac{1}{2}$ S, while under the conditions of Problem II. P equals $\frac{3}{4}$ S. For the conditions of practice it may be assumed without much error that the ends at A and E meet with such resistance to turning that the value of P is half way between $\frac{1}{2}$ S and $\frac{3}{4}$ S, which is $\frac{5}{8}$ S. This will alter the moment diagram shown in Fig. 2, by a triangular diagram of negative moments having a base of $\frac{1}{8}$ S l at E and an apex at D, and by a similar triangle between A and B. The influence of this modification in the moment diagram will be to give a numerical factor of $\frac{48}{11} = 4.363$ in the formula for S, instead of 4 or 4.8, as in equations (9) and (16).

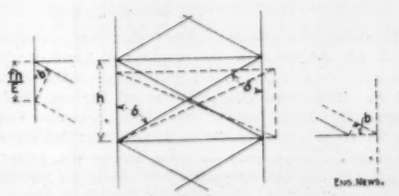


Fig. 5.

In solving Problems I. and II. the usual practice was followed of neglecting the influence of

the web on deflection. Where the web consists of solid plates and the column is not very short this gives a fair approximation, but where the column is short and the web is composed of lattice bars it may lead to serious error, especially if the lattice bars are light.

From Eq. (20) the length of the lattice bars equals $h/\cos b$. The stress equals

$$\frac{\text{shear}}{\sin b}$$

The change in length of the lattice-bar is

$$\frac{h \times \text{shear}}{E B^1 \cos b \sin b} \quad \ldots\ldots\ldots\ldots (28)$$

where B^1 is the cross-sectional area of all the lattice-bars in a panel.

This change in length will cause a deflection Δ_s (in the direction of the shear) of any point in the axis of the column beyond the panel of strained lattice, with reference to any point in the axis preceding the said panel, given by the equation,

$$\Delta_s = \frac{h \times shear}{E\,B^1 \cos b \sin b} \div \sin b = \frac{h \times shear}{E\,B^1 \cos b (\sin b)^2} \quad (29)$$

The deflection Δ_s for an entire column with equal lattice-bars, when the shear is constant, is then

$$\frac{l \times \text{shear}}{E B^1 \cos b\,(\sin b)^2} \quad \ldots\ldots\ldots\ldots (30)$$

and for one-half of the column

$$\Delta_s = \frac{l \times \text{shear}}{2E B^1 \cos b\,(\sin b)^2} \quad \ldots\ldots\ldots (31)$$

Considering the influence of the web and assuming, as above, that $P = \frac{5}{8} S$, Eq. (7) becomes

$$\Delta_1 = \frac{S l^2}{48 E I} - \frac{S l}{2 E B^1 \cos b\,(\sin b)^2} \quad \ldots (32)$$

and Eq. (8) becomes

$$\frac{S l^3}{6EI} + \frac{7 S l^3}{48 EI} - \frac{S l^3}{48 E I} - \frac{S l}{2 E B^1 \cos b (\sin b)^2} + \frac{5 S l}{8 E B^1 \cos b (\sin b)^2} = l \tan a + \frac{3 S l^3}{48 E I} - \frac{3 S l}{2 E B \cos b (\sin b)^2} \quad \ldots\ldots (33)$$

or

$$\frac{11 S l^3}{48 E I} = l \tan a - \frac{13 S l}{8 E B^1 \cos b (\sin b)^2}$$

$$S = \frac{48 E I \tan a}{11 l^2} - \frac{78 S I}{11 l^2 B^1 \cos b (sin\ b)^2} \quad \ldots\ldots (34)$$

The first term of the second member of this equation shows the effect of the bending moment and the second term the effect of the shear. The shear itself is found from this equation to be:

$$S = \frac{\frac{48 E I \tan a}{11 l^2}}{1 + \frac{78 I}{11 l_2 B^1 \cos b\,(sin\ b)^2}} \quad \ldots (35)$$

It should be observed from this last equation that an increase in the combined area of the lattice-bars per panel, B^1, will increase the value of S. Therefore the addition of batten plates, especially long heavy ones, will increase the value of S. In this connection it may be stated that the change in web area where the lattice-bars join the batten plates will cause an angular change in the line of deflection from web stresses which will tend to sharply bend the channels at these points, thereby causing local stresses.

If the angle by which the ends of the adjacent columns fail to abut at points B and D (Figs. 2 and 3), instead of being caused by a tilt in the middle column, is due in whole or in part to imperfect facing or to accidental distortion from an eccentric blow received in falling (or otherwise) whereby an originally rectangular column is made rhomboidal, precisely the same equations will result for the values of P, S and W. If an imperfect butt occurs at one joint only, the analysis is similar but the values of S and W are smaller than for the cases analyzed.

After the load W, which will just bring the joints into contact, has been reached, any additional load will not increase the primary bending moment from imperfect butt joints, which is a fact favorable to the strength of columns.

In proportioning columns, provision should be made for the greatest imperfection in facing combined with the greatest tilt in erection to which they are reasonably liable.

EXAMPLE.—To illustrate the effect of imperfect butt joints consider a line of three equal columns, each 67 ins. wide and 57 ft. long, with a tilt in the middle column of $^5/_{32}$-in. in 57 ft. (about $^1/_{64}$-in. in 67 ins.) and errors in facing each of the abutting surfaces at the ends of the middle column of $^1/_{64}$-in. in 67 ins.; each column composed of four equal channels with a combined cross-sectional area of 800 sq. ins., and a moment of inertia of 311,000, connected on each face by double 45° lattice, 4 × 3 × ⅜-in. angles, and single cross-ties 3½ × 3 × ⅜-in. angles between the panels of lattice. Under the conditions assumed, if the errors are cumulative, the adjacent end faces of the unstrained columns will fail to abut by $^3/_{64}$-in. in 67 ins. and the tangent of the angle of imperfection, tan a, will be 0.0007.

Substituting the assumed properties and dimensions in Eq. (35) gives

$$S = \frac{60900}{2.344} = 25{,}900 \text{ lbs.}$$

The stress in each lattice-bar will be 9,200 lbs. and W will equal 760,000 lbs.

If the imperfection is four times as great, the stress in each lattice-bar will be 36,800 lbs., and W will equal 3,040,000 lbs.

To these stresses in the lattice bars, there should be added the direct compression which, as shown under Problem IV., has an intensity equal to about 28% of the compression per square inch in the channels, say for instance 28% of 15,000 lbs. multiplied by the area 2.48 sq. ins., equals 10,400 lbs.

In addition to direct compression and accidental stresses from imperfect end connections, the lattice-bars are liable to accidental stresses from variations in the elasticity and sectional area of the channels and curves or kinks in the alinement of the column axis. The lattice-bars are also liable to the secondary stresses which may result from the deformation of the structure and the column. What provision should be made for such contingencies? Some years ago the writer originated the following rule, which he published in The Lehigh Quarterly, June, 1891, (Vol. 1, p. 159) and adopted as a clause in the New Jersey Steel & Iron Co.'s specifications:

> The lattice bars shall be so spaced that each channel between lattice connections shall be stronger than the column considered as a whole, and their size shall not be less than would be obtained by treating the column as a lattice girder supported at the ends and loaded at the middle with a load equal to 3% of the total compression on the column.

This clause expresses the writer's previous practice. It has determined the lattice on fairly large columns and the sizes used in estimating on very large ones. Recently, both before and since the fall of the Quebec Bridge, the writer has given considerable thought to this subject, but before coming to a final conclusion he prefers to wait for further developments regarding the Quebec Bridge disaster, and for discussion by those in charge of shop work, inspection and erection, as to the magnitude of the defects in end connections and alinement to which columns are liable.

THE OPERATING METHODS OF ELECTRIC RAILways are to be investigated by the Illinois Railroad Commission, as a result of the recent serious accident at Charleston, Ill. The interurban railways have all been notified to furnish detailed statements as to their methods controlling the movements of cars or trains and the general handling of traffic.

COMPLETION OF THE SURVEYS FOR THE MONTREAL, OTTAWA AND GEORGIAN BAY SHIP CANAL.

By J. A. McDONALD.*

Now that the survey of the Montreal, Ottawa and Georgian Bay ship canal line has been completed and in such detail as not only to determine the most economical and feasible route, but to afford data for a close estimate of cost, there may be looked for at the next session of the Canadian Parliament an announcement that the Government has decided to proceed with the work of construction. For the prime minister has practically committed his administration to the undertaking.

The survey recently completed has required nearly three years' hard work by a competent staff of engineers. Comencing at Georgian Bay, the line proceeds up the French River by one of its five estuaries, known as the French River Channel, to the village of that name, where the first lock is encountered. By this lock the line is taken into the Pickerel River, which is followed for 37 miles to the second lock, then a lift of 24 ft. brings the canal again into the French River. This stream is utilized for a distance of 14 miles to the third lock. Another lift of 24 ft. at this point and then comes a stretch of practically free navigation in Lake Nipissing extending for 32 miles, at the end of which is a lock that elevates the east-bound craft from Lake Nipissing into Trout Lake. Here the summit is reached, 677 ft. above sea level, and 24½ miles long, mainly free navigation, but requiring small cuttings at places where the channel is contracted. The channel leads directly into Lake Talon (an expansion of the Mattawa River), which is to be raised 37 ft. by a dam constructed at the head of Talon falls. The summet level, therefore, extends from Trout Lake to Talon falls. The run-off from the drainage area supplying this level, however, was not deemed to be sufficient to work the canal system to its full capacity, and a painstaking search for additional supply was instituted. The river Amable du Fond, flowing northward, empties into the Mattawa lower down, and it was found that by means of a flume and tunnel it could be diverted so as to empty into the summit level, thus giving a large surplus of water.

Leaving the summit level the line passes to the north of the main channel of the Mattawa River, across quite a high divide and thence into the level below, through two flights of locks of 60 ft. each, a drop of 120 feet. Following down the Mattawa, the Ottawa River is reached at the town of Mattawa after a passage through three locks, one at Les Epines rapids, one at Champlain chute, above Mattawa, and one lock located at the town of Mattawa itself, a fall of 57 ft. in the three, or a total drop of 177 ft. from the summit.

This section involves the heaviest work of the whole line, but its close proximity of the line of the Canadian Pacific railway eliminates the feature of excessive cost of transportation of supplies, etc., so that the cost will be reduced to the minimum for this class of work.

From Mattawa to the City of Ottawa, below the Chaudiere falls, there are 12 locks, with a total fall of 360 ft., and at three points locks are grouped in flights. One of these flights is to be at Ottawa to overcome the falls, a drop of 55 ft. between the levels above and below the Chaudiere falls. The other flights are to be at the Chats falls and the Rocher Capitaine rapids. The single locks will be at the Cheneaux rapids, the Rocher Fendu, the Paquet rapids and the Des Joachims.

From Ottawa to Montreal the main channel of the Ottawa River is followed, five single locks being utilized to bring the proposed waterway to the level of the St. Lawrence. These locks would be at Hawkesbury, Point Fortune, Ste. Anne and Verdum, and finally one opposite the custom house in Montreal.

On account of expected opposition to the adoption of the latter section of the route, because of the frequent crossings which it will involve of the trunk lines of railway centering in Montreal, another route which would obviate this difficulty has been investigated. It proceeds by the River

*104 Queen St., Ottawa, Can.

Des Prairies back of Montreal and will debouch upon the St. Lawrence at Bout de Lisle, the descent being accomplished by three locks.

In all the canal from Georgian Bay to Montreal will be 400 miles long. From Montreal to the summit the distance is 334 miles, with a difference of 659 ft. in elevation; and from the summit westward it drops 99 ft. in 83 miles. The locks are to be of sufficient capacity to pass the largest freight boats on the lakes, vessels which are gradually approaching 625 ft. in length, and are even now 60-ft. beam, with a carrying capacity of 12,500 tons on a draft of 20 ft.

Such vessels are capable of carrying over 450,000 bushels of wheat. It is well known that from the head of lake navigation to Liverpool, the saving in distance by the Georgian Bay canal route is nearly a thousand miles, as compared with the Chicago-New York route, which also involves the disadvantage of a long carriage by the Erie, a mere barge canal. As compared with the St. Lawrence canal route, the Ottawa and Georgian Bay canal would effect a saving in distance of nearly 400 miles in the transportation of grain from the lakes to the head of Atlantic navigation. On the basis of last year's freight charges this would mean a saving of nearly 34 cts. per ton, or about 1 ct. per bushel on wheat, in favor of the Ottawa route.

Last year nearly fifty-five million bushels of wheat alone were transported by vessels via the existing longer routes. The magnitude of the traffic in which the new canal would participate under advantageous conditions may be further estimated from the fact that the value of freight passing through the Soo canals last year was $557,464,000, upon which the freight earnings were $36,667,000.

The development of electrical power is another important consideration in connection with the construction of the Georgian Bay canal. A conservative estimate places the water power development which will be rendered available by the navigation dams at 80,000 HP., an asset of $800,000 yearly at the low price of $10 per HP.

One of the most important features of the projected undertaking, affecting the City of Ottawa particularly, is the regulation of the water supply of the Ottawa River. The range of flow of the Ottawa at this city is from a maximum of 194,000 cu. ft. per sec. to a minimum of 12,000. By the system of dams and reservoirs required for the operation of the canal, a mean flow would be maintained the year round.

Estimates of the approximate cost of the canal which have been given out of late will be found to be based upon mere guesswork and superficial knowledge of the ascertained conditions. None of these, it may be taken for granted, has been authorized or endorsed by the department of public works, under whose auspices the survey has been conducted.

These estimates have placed the cost at about $105,000,000. This, it is now believed, is over five per cent. in excess of the actual estimate based upon the survey just completed.

NOTES FROM ENGINEERING SCHOOLS.

ATCHISON, TOPEKA AND SANTA FE RY.—This road proposes to establish in its Topeka shops a school for apprentices. Five old and experienced employees will be selected as instructors, 25 boys being assigned to each instructor. The apprentices will be instructed in mechanical drawing, practical mathematics, elementary mechanics and shop work. The instruction will be given from 7 to 9 a. m. and from 1 to 3 p. m., after which the apprentices will return to regular work.

LEHIGH UNIVERSITY.—The new heating and lighting plant made necessary by the worn-out condition of the old heating plant and for lighting the new buildings is expected to be placed in service during the coming winter. The building for the plant is provided by an extension and duplication of the steam laboratory. The combined building will be 40 x 175 ft., with a boiler room 90 ft. long, including the boiler equipment of the steam laboratory, and an engine room 81 ft. long. Natural draft for three 250-HP. Stirling boilers will be furnished by a new 125-ft. stack, built of radial brick. Coal storage is provided by a yard 60 ft. square. It is planned to install automatic conveying and elevating machinery to handle coal and ashes. The engine room is designed to accommodate three generating sets with all necessary auxiliary apparatus. Two of these sets, to be immediately installed, are of 50 and 100 HP., respectively.

NEW YORK UNIVERSITY.—An evening course in industrial engineering, intended to give manufacturers, contractors and their employees a working knowledge of engineering principles which enter into the construction and operation of their plants, was begun on Sept. 26 under the direction of Dean Joseph F. Johnson at the School of Commerce, Accounts and Finance in Washington Square. This course has been designed particularly to aid those connected with industrial concerns to inspect, intelligently, specifications and materials, and to pass on plans for application of power to various types of machinery. Supplementing this will be courses in industrial chemistry, which will deal with the chemical processes in the manufacture of extensively used commodities; in industrial values, to enable the manufacturer or selling agent to interpret his market, and in business organization, which will consider methods of securing economical management of production and sales departments and effective placing of products under varying conditions of trade. Detailed information may be obtained from the secretary of the School of Commerce, Accounts and Finance, Mr. W. H. Lough, Jr.

THE WORST RAILWAY WRECK of the past week occurred on the afternoon of Sept. 28, on the Baltimore & Ohio R. R. at Bellaire, Ohio. Owing to the failure of an operator to throw a switch, the eastbound Chicago and Wheeling express ran into a siding and collided head-on with a freight slowly moving westward thereon. Fifteen persons were killed and 21 injured; and as in several of the more serious wrecks lately, most of the casualties were in the smoker, in which every passenger was either killed or badly injured. The operator involved has stated that a few minutes before the accident he had seen several foreigners tampering at the switch where it occurred; investigations are being made of this suggestion of malicious work.

The Ohio interurban electric lines again contributed to the accident record when a head-on collision occurred on Sept. 28 on the Toledo, Port Clinton and Lakeside line near Elmore, Ohio. One man was killed and eight other persons injured—two seriously. The cars—one a freight car—met on a sharp curve. This is the first accident which has occurred on this particular line since it was opened about three years ago.

Four persons were killed on Sept. 29 in a collision on the Seaboard Air Line Ry., between a freight train and a work train near Alamo, Ga. The wreck was due to a washout.

The fast train on the St. Louis & San Francisco R. R., known as the "Meteor," was derailed and wrecked on Sept. 30 near Dixon, Mo. Two persons were killed, one seriously injured and a number less so. The train was speeding down a steep 16-mile grade. On the same road the night before a head-on collision occurred between a Texas limited train and a freight train near Stanton, Mo., killing three persons and injuring about twenty.

The buckling of a freight train on the Pennsylvania R. R. near Duncannon, Pa., on Sept. 27, wrecked an Altoona accommodation train and caused the injury of ten persons.

A narrow escape from a serious terminal wreck on the Erie R. R. occurred on Sept. 25, when the engineer of the "Nyack Flyer" was knocked unconscious by a telegraph pole as the train was nearing Jersey City. Failure to slow down, in passing over the switches in the yards, apprised the fireman barely in time.

A rear-end collision occurred in France on Sept. 25, when the regular Rouen express telescoped the rear car of a special steamer train for Cherbourg at the mouth of the Breval tunnel near Mantes. No one was killed, but two were seriously injured.

A BURNING CAR in the Belmont tunnel under the East River, New York City, thoroughly frightened the passengers who were making the trip at the invitation of the tunnel company. The car was on the return trip from Manhattan to Long Island City and had reached a point under Man-'o-War Reef when the trouble occurred. Blue flames began to play between the steel roof and the overhead contact rail and the thin plates forming the car roof showed red and peeled back, allowing the flame to reach the woodwork. The car was run toward Long Island City at full speed, but stopped just before it reached the first station. The passengers made their exit to the surface safely from this point. The fire was easily extinguished with chemicals. Press reports give the cause as faulty insulation of the contact device or a short circuit due to an accumulation of iron particles from the overhead rail.

PERSONALS.

Mr. Max Ruess has been appointed Chief Engineer of the Filer & Stowell Co., of Milwaukee, to succeed Mr. Marcel Foucard.

Mr. J. E. Ham has been appointed representative of the Waterbury Co., manufacturers of rubber, insulated wire and cable, with offices at 108 La Salle St., Chicago.

Mr. Joseph O'Hara, Superintendent of the Aurora, Elgin & Chicago Electric Ry., has been appointed to a similar position on the Washington, Annapolis & Baltimore Electric Ry.

Mr. J. W. Brophie, for two years Master Mechanic of the Atlanta Steel Co., of Atlanta, Ga., has resigned to take the same position with the Ontario Steel & Iron Co., of Welland, Ont.

Messrs. Chas. F. Parker, M. Am. Inst. M. E., and Chas. J. Carroll, have opened offices as consulting mining engineers at Torreon, Coahuila, Mex., under the firm name Parker & Carroll.

Mr. Geo. W. McClure, Superintendent of the Norwich & Westerly (Conn.) Electric R. R., has resigned to become Superintendent of Construction and Equipment of the Illinois Traction system, with offices at Danville, Ill.

Mr. Albert Carr, Chief Engineer of the United Railroads of San Francisco, has resigned to take the position of Superintendent of Construction on the water power developments of the Central Colorado Power Co., with headquarters at Colorado Springs.

Mr. H. Montgomery has been appointed Superintendent of Motive Power and Equipment of the Bangor & Aroostook R. R., with offices at Milo Junction, Me. The position of assistant to that office, formerly held by Mr. Montgomery, was abolished Oct. 1.

Mr. Frederick L. Smith has opened offices at 5 Beekman St., New York City, for practice as a consulting industrial engineer. For the past six years Mr. Smith has been in charge of the New York City office of Mr. Joseph H. Wallace, Industrial Engineer.

Messrs. M. S. Parker and Arthur H. Buck, M. Am. Inst. M. E., have organized the firm of Parker & Buck, Consulting Mining Engineers, with offices in the Bartlett Building, Joplin, Mo. Mr. Buck was formerly with the Continental Mining Co., of Coahuila, Mex.

Mr. J. V. Nimmo, Assoc. M. Am. Soc. C. E., of Paspebiac, P. Q., has resigned the position of Chief Engineer of the New Canadian Co., Ltd., and Resident Engineer of the Atlantic, Quebec & Western Ry. His duties are temporarily undertaken by Mr. W. Lyon Browne.

Mr. Gerard H. Matthes, for ten years an engineer with the U. S. Reclamation Service and also connected with the Division of Hydrography, U. S. Geological Survey, has resigned to accept a position in the office of Mr. Robert McF. Doble, Consulting Engineer of the Colorado Power Co., of Colorado Springs.

Mr. S. A. Jordan has been appointed Division Engineer of the Philadelphia division of the Baltimore & Ohio R. R., with headquarters at Philadelphia. He succeeds Mr. A. A. Miller, resigned. Mr. Jordan is succeeded as Division Engineer of the Cleveland division by Mr. E. V. Smith, formerly Supervisor at Cleveland.

Mr. T. J. English, Division Superintendent on the Erie R. R. at Youngstown, O., has been made Assistant to the General Manager. Mr. F. J. Maser, Division Superintendent at Huntington, succeeds Mr. English, and Mr. E. C. Allen, Assistant Superintendent at Galion, succeeds Mr. Maser at Huntington, in charge of the Chicago and Erie divisions.

Mr. W. L. Mattoon, Division Engineer of the Zanesville & Western and Corning divisions of the Toledo & Ohio Central Ry., has been appointed Principal Assistant Engineer of the Hocking Valley and Zanesville & Western Rys., with offices at Columbus, Ohio. Mr. D. C. Holtsberg, formerly Division Engineer of the Eastern division of the Toledo & Ohio Central, succeeds him in his former position, and Mr. R. P. Black, formerly with the Pennsylvania Lines West of Pittsburg, succeeds Mr. Holtsberg at Bucyrus, Ohio.

Mr. Elwood Mead, M. Am. Soc. C. E., for a number of years past Chief of Irrigation and Drainage Investigations, Office of Experiment Stations, U. S. Department of Agriculture, with headquarters at Washington, D. C., has resigned from that position (effective Sept. 30). He will sail for Melbourne, Australia, on the "Moana" from Vancouver on Oct. 11, to become Chairman of the Commission on Rivers and Water Supply of the State of Victoria. Since July 1, 1907, Mr. Mead has been on leave of absence from the position first named in this note, and has been engaged with the Denver Reservoir Irrigation Co. on a large project for constructing irrigation works not far from Denver, Colo.

Mr. B. M. Hall, M. Am. Soc. C. E., M. Am. Inst. M. E., Consulting Engineer, of Atlanta, Ga., has just returned from a two months' trip to Porto Rico, where he is employed by the Insular Government to make investigations and plans for irrigation of the rich sugar cane lands on the south coast. Having found feasible conditions, he has placed Mr. J. M. Giles, Assistant Engineer, in the field to make stream measurements and detailed surveys. Mr. Hall is also a Consulting Engineer in the U. S. Reclamation Service, devoting a part of his time to Western work. Mr. Giles is Assistant Engineer in the U. S. Reclamation Service, and has been temporarily transferred to Porto Rican work.

The firm of D. C. & Wm. B. Jackson have recently moved their Western office from Madison, Wis., to the new Commercial National Bank Building at Chicago; an Eastern office is also being opened in Boston. Mr. Dugald C. Jackson, the senior member of the firm, is best known from his work as Professor of Electrical Engineering at the University of Wisconsin, which position he held from 1891 until February of the present year. During that time he also developed a wide practice as consulting engineer, adviser and expert for various manufacturing and corporation interests. In February last he became Professor of Electrical Engineering at the Massachusetts Institute of Technology. Mr. Wm. B. Jackson, the junior member of the firm, graduated in 1890 from the course in mechanical engineering at the Pennsylvania State College, and later received a degree of Mechanical Engineer. After serving in various responsible engineering positions in various parts of the country, in November, 1902, he became associated with Mr. D. C. Jackson at Madison, Wis., as a consulting engineer. Both members of the firm are members of the American Institute of Electrical Engineers, the American Society of Civil Engineers and the American Society of Mechanical Engineers. Mr. Wm. J. Crumpton will be in immediate charge of the Chicago office; he is a graduate from the course in electrical engineering at the University of Wisconsin and has had several years of experience.

Obituary.

George Lewis Heins, State Architect of New York, died on Sept. 25, at his home near Peekskill, N. Y. He was born in Philadelphia in 1860. He studied architecture at the Massachusetts Institute of Technology, where he graduated in 1882. His apprenticeship was served in an architect's office in Minneapolis, and also in St. Paul; he then came to New York City, where he became associated in 1886 with Christopher Grant LaFarge, the painter, their partnership continuing until Mr. Heins' illness.

In 1899 Gov. Roosevelt appointed him State Architect. Since his appointment all of the State buildings erected have been of his design. He was a leading authority on church architecture, and designed the Cathedral of St. John the Divine, now under construction at New York City, and a number of other prominent New York churches. The buildings in the New York Zoological Gardens were also of his design; and the firm were consulting architects for the Rapid Transit Commission.

Mr. Heins was a member of the American Institute of Architects, the Architectural League, the Century, Calumet, Racquet, University and Underwriters' Clubs, and the Fort Orange Club of Albany.

Leveson Francis Vernon-Harcourt, M. Inst. C. E., one of England's distinguished engineers, and one of wide experience in river and harbor work, etc., died on Sept. 14 at Swanage, England. He was the youngest son of the late Admiral F. E. Vernon-Harcourt, and was born in 1839. His early education was received at Harrow, and he afterwards went to Balliol College, Oxford, where he took degrees in 1861 and 1862. For three years thereafter he was with the late Sir John Hawkshaw, F. R. S., President in 1861 of the Institution of Civil Engineers; he then became Resident Engineer of the Southwest India Dock Works. Holding various other positions in the line of harbor work, he began practicing as a consulting engineer in 1878, at the age of 39. In 1882 he was appointed Professor of Civil Engineering at University College, London, and was made Emeritus Professor in 1906.

Mr. Vernon-Harcourt was regarded as an authority on canal and river engineering, and particularly on the subject of hydraulic canal lifts. In 1904 he was a member of the International Jury at Vienna, on projects for canal lifts; for his services at that time he was made a Commander of the Imperial Franz Josef Order of Austro-Hungary. The deposition of silt in channels and at ports was also one of his principal studies.

In 1896 Mr. Vernon-Harcourt went to India to make a report to the Port Commissioners of Calcutta on the improvement of the Hooghei River. He also served on the Juries of Award for Civil Engineering at the Paris Exposition of 1900 and the Louisiana Purchase Exposition in 1904. In 1905 he represented England at the Navigation Congress held at Milan, and in 1906 was appointed as British member of the Consultative Commision for the Suez Canal.

ENGINEERING SOCIETIES.

COMING MEETINGS.

NATIONAL ASSOCIATION OF RAILWAY COMMISSIONERS.
Oct. 8. Annual meeting at Washington, D. C. Secy., Edw. A. Moseley, Interstate Commerce Commission, Washington, D. C.

RAILWAY SIGNAL ASSOCIATION.
Oct. 8-10. Twelfth annual meeting at Milwaukee. Secy., C. C. Rosenberg, Lehigh Valley R. R., South Bethlehem, Pa.

AMERICAN BOILER MANUFACTURERS' ASSOCIATION.
Oct. 8-10. Nineteenth annual convention at Atlanta, Ga. Secy., J. D. Farasey, Forest St. and Erie Ry., Cleveland, O.

INTERNATIONAL ASSOCIATION OF FIRE ENGINEERS.
Oct. 8-11. Thirty-fifth annual convention at Washington, D. C. Secy., Jas. McFall, Roanoke, Va.

AMERICAN STREET AND INTERURBAN RAILWAY ASSOCIATION.
Oct. 14-18. Annual convention of this and affiliated association at Atlantic City, N. J. Secy., Bernard V. Swenson, 29 West 39th St., New York City.

AMERICAN STREET AND INTERURBAN RAILWAY ENGINEERING ASSOCIATION.
Oct. 14-16. Annual convention at Atlantic City, N. J. (See preceding item. Secy., S. W. Mower, Southwestern Traction Co., London, Ont.

ASSOCIATION OF RAILWAY SUPERINTENDENTS OF BRIDGES AND BUILDINGS.
Oct. 15-17. Annual meeting at Milwaukee. Secy., S. F. Patterson, Concord, N. H.

AMERICAN GAS INSTITUTE.
Oct. 16-18. Second annual meeting at Washington, D. C. Secy., Jas. W. Dunbar, New Albany, Ind.

AMERICAL ELECTROCHEMICAL SOCIETY.
Oct. 17-19. Annual fall meeting at New York City. Secy., Prof. J. W. Richards, Bethlehem, Pa.

NATIONAL RAILWAY WATER SUPPLY ASSOCIATION.
Oct. 22-23. Annual meeting at Beloit, Wis. Secy., F. W. Hayden, Glencoe, Minn.

ROADMASTERS' AND MAINTENANCE OF WAY ASSOCIATION.
Nov. 11-14. Twenty-fifth annual convention at Chicago. Secy., W. E. Emery, C. & A. Ry., Kansas City, Mo.

AMERICAN MINING CONGRESS.
Nov. 11-16. Tenth annual convention at Joplin, Mo. Secy., J. F. Calbreath, Jr., Denver.

AMERICAN CIVIC ASSOCIATION.
NATIONAL MUNICIPAL LEAGUE.
Nov. 19-21. Joint convention at Providence, R. I. Secy., Clinton R. Woodruff, North American Building, Philadelphia.

SOCIETY OF NAVAL ARCHITECTS AND MARINE ENGINEERS.
Nov. 22-23. Annual meeting at New York City. Secy., W. J. Baxter, 29 West 39th St., New York City.

SOCIETY FOR THE PROMOTION OF INDUSTRIAL EDUCATION.
Dec. 5. Convention at Chicago. Secy., C. R. Richards, Teachers' College, New York City.

ENGINEERS' CLUB OF PHILADELPHIA.—A meeting was held on Saturday evening, Sept. 21. The paper of the evening was "An Illustrated Talk on a Recent Visit to the Quebec Bridge," by Mr. Silas G. Comfort, Assoc. M. Am. Soc. C. E., Vice-President and Professor of Engineering at the Pennsylvania Military College, Chester, Pa.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.—The first regular meeting of the season will be held in the auditorium of the Engineering Societies Building at 8.15 P. M. on Oct. 11. A paper will be presented on "The Grounded Neutral, With and Without Series Resistances, in High-Tension Systems," by Paul M. Lincoln; experience papers on the same subject will be presented by F. G. Clark, of the Pennsylvania Tunnel & Terminal R. R. Co., and Geo. I. Rhodes, of the Interborough Rapid Transit Co.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.—The first monthly meeting of the fall will be held in the main auditorium of the Engineering Societies Building on Oct. 8, at 7:45. The subject of the meeting will be Industrial Education. Prof. John Price Jackson of the Pennsylvania State College, will present a paper on "The College Technical Courses, and the Apprenticeship Courses Offered by Manufacturing Establishments," in which the data will be given in the form of letters from several of the largest firms in America. Dr. Henry S. Pritchett, President of the Carnegie Foundation and of the Society for the Promotion of Industrial Education, and ex-President of the Massachusetts Institute of Technology, will deliver a short address, as will also Prof. Dugald C. Jackson, head of the Department of Electrical Engineering at the Massachusetts Institute of Technology and ex-President of the Society for the Promotion of Engineering Education. A number of manufacturers are expected to speak informally, and the meeting will be one of considerable interest in the direction of education.

CANADIAN ELECTRICAL ASSOCIATION.—The seventeenth annual convention was held in Montreal on Sept. 11, 12 and 13. Conventions were held also by the Canadian Street Railway Association and the Maritime Electrical Association.

The report of the secretary pointed out that the use of electric light in Canada has increased over 100% in five years. Mr. R. G. Black, the President, in his address pointed out that the problem of earning dividends was growing harder instead of easier; as a way out of the difficulty, he suggested the extension of the use of electric energy for electric heating and cooking and for household purposes generally.

A list of the papers was given in this column on Sept. 5. The election of officers for the ensuing year resulted as follows: President, R. S. Kelsch (M. Am. Inst. E. E.), Consulting Engineer, Montreal; Vice-President, W. N. Ryerson (M. Am. Inst. E. E.), Superintendent Ontario Power Co., Niagara Falls, and R. M. Wilson (Assoc. Am. Inst. E. E.), Montreal Light, Heat & Power Co.; Secretary-Treasurer, T. S. Young (reelected).

ROADMASTERS' AND MAINTENANCE-OF-WAY ASSOCIATION.—The twenty-fifth annual convention will be held at the Sherman House, Chicago, Ill., on Nov. 12 to 14. The committee reports to be presented are as follows: 1, Maintenance of line and surface in winter; 2, Methods of destroying vegetation in the track, including weed burners; 3, Wrecking outfits, organization and working; 4, Cost of ballasting old track and renewing ties; cost of relaying rail; organization and working. There will also be the following individual papers: "The Oiling of Roadbed," J. C. Rockhold; "Special Construction on the Cincinnati Southern Ry." C. J. Murphy; "Track Work as Skilled Labor," W. M. Camp. Topical discussions will be introduced for the first time and will include the following: 1, Paving ditches; 2, Length and size of ties; 3, Draining the middle of double track (by surface ditches or by tile drains); 4, Should the gage on curves be adjusted for wear of the rail head; if so, which rail should be moved; 5, Quality of track labor. President, C. H. Cornell (Chicago & Northwestern Ry.), Antigo, Wis.; Secretary, W. E. Emery, Engineer of Maintenance of Way (Chicago & Alton Ry.), Kansas City, Mo.

INTERNATIONAL ASSOCIATION OF FIRE ENGINEERS.—The thirty-fifth annual convention will open in Washington, D. C., on Oct. 8, and extend through Oct. 11. Papers to be presented are listed below: "Are Shingle Roofs in Cities Conflagration Hazards," Chief T. W. Haney, Jacksonville, Fla.; "Fire Protection for Private Corporations," Herbert Hester, Fire Marshal P. R. R., Philadelphia; "Is Fire Prevention of More Importance than Fire Protection?" H. C. Henley, Chief Insp., St. Louis Fire Prevention Bureau; "Fire-Boat Protection," Chief Edw. F. Croker, New York City; "Extinguishing Fires in Cellars and Subcellars," Chief C. E. Swingley, St. Louis; "Electric Fires—Their Cause and Prevention," W. H. Merrill, Secy. Nat'l Fire Protection Assn.; "What Are the Dangers of Carbon Bisulphide in Liquid Form, and the Best Methods of Handling and Storing It?" Chief. J. R. Canterbury, Minneapolis.

Among the topics scheduled for formal discussion are: "Faulty Building Construction"—from the fire standpoint; "The Advisability of Using Explosives to Check Conflagrations"; "Transportation of Fire Apparatus in Event of Sending Aid to Other Cities"; "Should Telephones be Installed in Fire-Alarm Boxes?" "Shut-Off Nozzles on Engine Streams"; "The Use of 3-in. Hose."

AMERICAN STREET AND INTERURBAN RAILWAY ASSOCIATION.—The twenty-sixth annual convention will open at Atlantic City on Oct. 14. The four allied associations—the American Street and Interurban Railway Engineering, Accountants', Claim Agents', and Manufacturers' Associations—will convene there at the same time. The Marlborough-Blenheim will be the headquarters hotel of the American Association and of the Manufacturers, the Dennis of the Engineers, the Chalfonte of the Accountants, and the St. Charles of the Claim Agents. While the meetings of the affiliated associations individually will begin on Oct. 14, the opening session of the American Association and joint meeting of all associations does not come until Oct. 16.

Meetings of the various associations will be held simultaneously, at various places of assembly. The Steel Pier will be given over to the convention. Among the many papers arranged for presentation at various sessions are the following:

American Association.—"The Technically-Trained Man and the Electric Railway Profession," Prof. H. H. Norris, Cornell; "The National Fire-Protection Association and Its Work in the Street and Interurban Railway Field," Ralph Sweetland, Boston; "Influence of the Design of Railway Structures on Economy of Operation," H. J. Campion and Wm. McClellan, Consulting Engineers, New York City; "Use of T-Rails in Cities," C. Gordon Reel, Kingston, N. Y.; "Municipal Ownership in Great Britain and the United States," Wm. J. Clark, New York City.

Engineering Association.—"Operating Features of Curtis Turbines," Aug. J. Kreusi, G. E. Co., Schenectady; "Recent Developments in Steam-Turbine Power-Station Work," J. R. Bibbins, Westinghouse Machine Co., E. Pittsburg; report of Way Committee—"Rail Corrugation Investigation;" report of Way Committee—"Concrete Tie Investigation;" report of Sub-Committee—"Rails and Rail Matters;" report of Committee—"Operating and Storage Car-House Designs."

Claim Agents' Association.—"Instructions to Employes in the Work of Preventing Accidents," F. W. Johnson, Philadelphia Rapid Transit Co.

The Manufacturers' Association is preparing for an exhibition of street railway apparatus which is expected to surpass all previous ones, and which will cover the entire Steel Pier. Over 200 spaces have already been assigned.